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## DAMAGE BY ICE TO THE STAND-PIPE AT COBOURG, ONT., AND THE REPAIRS THERETO.

By H. C. Hodgkins.*

The stand-pipe of the water-works of Cobourg, Ont., is 16 ft. in diameter and 104 ft. high. It is located about one-half mile from Lake Ontario, from which the water is pumped. When the stand-pipe is full the gage at the pump house shows 70 lbs. pressure.

The first three sheets from the bottom are 7/16-in. thick; the next three are 13/32; and the next three are 3/8-in. thick. The sheets are 4 ft. 2½ ins. wide, 4 ft. c. to c. of rivets, and 8 ft. 10 ins. long, including vertical laps.

About 10 p. m., Monday, March 28, 1904, the stand-pipe burst, as is shown by the accompanying view. Sheets C and A (Fig. 1) in the sixth ring from the bottom gave out by tearing along the vertical seam, leaving the lap riveted on. The sheets tore right along the horizontal joints, leaving some of the rivets in one sheet and some in the other. Sheet A was bent outward its entire length until it stood nearly normal to the surface of the stand-pipe. Sheet C was turned outward in a similar manner for half its length. The sheets in the seventh ring were only damaged along their lower edge. Those in the fifth ring were torn downward in eight places from 10 to 20 ins., and the vertical joint of sheets F and G was torn apart for nearly half its length. The torn portions of these sheets were bent outward by the pressure of the escaping ice.

VIEW SHOWING STAND-PIPE DAMAGED BY ICE AT COBOURG, ONT.

The break was on the northerly side. A great quantity of ice was forced through the opening with sufficient force to take away the fence and cut down electric light poles and carry large cakes of ice across the street, a distance of 250 ft. The ice was accurately shaped to the sides of the stand-pipe and was 4 ft. thick.

After the accident the water was drawn out of the stand-pipe, and the latter was found to be full of large chunks of ice, the largest dimension being vertical up to the break, and a hollow cylinder of ice extended about 25 ft. above the break, being apparently thicker on the north than on the south side.

The water-works and the electric lighting are operated from the same station. During the winter it was the custom to have the stand-pipe full at about 7 p. m., and to start pumping again when the pressure got down to 50 lbs.

On Saturday, March 26, ice was seen projecting about 4 ft. above the top of the stand-pipe. On Sunday the engineer, standing at the pump-house, saw the ice projecting, as he estimated, 2 ft. above the stand-pipe. The weather remained warm, and it was perfectly calm Monday and Monday night. The engineer stopped pumping at 7 p. m., with a water pressure of 70 lbs. About ten minutes before the accident happened the gage showed a pressure of 52 to 53 lbs. The engineer expected to start his pumps at that time but as the pressure was holding up better than usual he delayed doing so, and had not started them when he was informed of what had happened.

### REPAIRS.

The repairs were undertaken by the Canada Foundry Co., of Toronto, Ont. The sheets were rolled, scarfed and punched for the vertical seams at the shop. The stand-pipe had been thoroughly guyed immediately after the accident. A test with a plumb line showed the stand-pipe to be leaning to the north about 6 ins. By means of blocks and wire cables, it was drawn back until it appeared to be but 3 ins. out of plumb. Four rivets were taken out of each vertical seam, marked X in the fourth and eighth rings. Four 4 x 6-in. angle-irons were then marked, drilled and bolted up across the fifth, sixth and seventh rings in the positions marked X X. The angle-irons at the extreme right and left were placed on the inside, and the other two on the outside of the stand-pipe.

Sheets A, D, E, F, and G were then taken out, and sheet C was cut off 14 ins. beyond, or to the left of, the vertical seams in the rings above and below, and sheet B was cut off 12 ins. to the left of the vertical seams in the rings above and below. The new sheets for D, E, F and G were then bolted up in place and marked for the rivet holes to join them to rings 4 and 8. The sheet to take the place of A was marked for rivet holes from a templet, and the corresponding holes in the sheets to which it was to be riveted were marked from the same templet. After these five sheets were bolted in place, the small sheets were marked, punched and bolted in place. The back row of holes in the vertical seams for C and B had to be drilled. The small sheet B was left off until the last to allow the men to pass in and out. All the other sheets were securely drawn to place by bolts in every other rivet hole. After the plates were bolted in place the angle-irons were removed and the riveting proceeded with.

The repairs were finished July 6, 1904, and the stand-pipe was filled with water. Only a few slight leaks were found that needed re-calking.

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## A SECTIONAL ROCK CRUSHER FOR MINING WORK.

In the design of machinery for use at mining plants it is very often necessary to combine ample strength (to resist wear and hard usage) with light weight, so as to provide for economical transportation on the rough trails leading to the sites where the machinery is to be installed. This combination is usually effected by building the machine in sections or parts, each of which is of comparatively light weight, and which when assembled will make a strong machine, not liable to become loose in the various joints. The accompanying cuts represent a rock and ore crusher, which is designed specially with a view to ease and economy of transportation. The total weight is about 7,300 lbs. (which is much lighter than that of ordinary machines of the same class), and the heaviest parts weigh only 300 lbs., so that they can be readily transported by mules on rough mountain trails. One of the greatest reductions in weight is effected by eliminating the usual heavy side frame castings, and substituting four machine bolts, 2½ ins. in diameter, to connect the stationary jaw with the main bearings. The oscillating toggle arm of the movable jaw is built up of a number of parallel plates, fitted together and secured by cross bolts. Each

of the two fly-wheels is also built up in four sections to facilitate transportation.

The bed plate is cast in two parts of channel section, set side by side, and to these are bolted the side frames which form the crushing hopper; to these frames is attached the end piece carrying the fixed jaw. The frames and bearings are connected by longitudinal bolts, with upset seats to rest against the faces of the castings. The movable jaw is suspended by two hangers, attached at the top to pins in the side frames, and at the bottom to pins in the jaw. Attached to the jaw is the oscillating toggle arm, built up of plates fitted and bolted together. The end of this arm has at the end a bearing in a faced recess in the back of the pitman, this forming the toggle joint. The pitman rides on the eccentric portion of the main shaft, and at its top is a cross shaft carrying cast steel side arms attached to another cross shaft on the front of the fixed jaw. The crushing strain is not thrown on the frame, but is sustained entirely by the side arms and cross shafts, which are of steel, having a tensile strength of 65,000 lbs. per sq. in. In case of a hammer head or other unbreakable substance being caught between the jaws, the strain will break a pin connection between the band wheel and the main shaft. This is done to prevent the breakage of the machine in parts less easily repaired. No back toggle is employed to support the pitman when crushing, this being unnecessary with the arrangement of side arms and cross shafts above described. The crushing chilled-iron crushing dies are fitted directly to the faces of the jaws, being held in place by dovetail seats at the bottom and taper bolts at the top, so that they are easily removed and replaced. The lubrication of the bearings is effected by wide boxes packed with waste and grease.

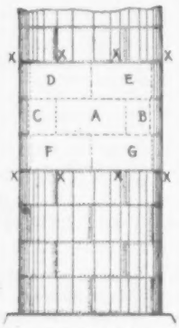



Fig. 1. Sketch illustrating Repairs to Stand-Pipe at Cobourg, Ont.

(The portion within the dotted line shows the parts replaced.)

The arrangement of the toggles and movable jaw is such that the jaw does not oscillate on a fixed pivot, as in that case the work would be done only on the forward stroke. Instead of this the jaw has no fixed center; the upper part first rocks forward, the whole jaw then advances, and finally the lower part rocks forward while the upper part at the same time recedes to give the full width of opening. The crushing is therefore continuous, and there is no loss of time or work in making the return stroke. The width of jaw opening can be regulated by turning the cross shaft which carries the side arms, the shaft being made slightly eccentric in the bearings. The arrangement of the machine, with all toggle connections at the top, enables the shaft to be placed much lower than is usually the case, so that the tops of the flywheels are almost on a level with the top of the jaws, and the whole machine can be decked over with a working platform.

This machine is being built by the National Drill & Mfg. Co., Pullman Building, Chicago, and we are indebted to the builders for plans and other information.

## SOME NOTES ON THE COST OF CINDERS FOR SEWAGE FILTER BEDS.

By Ernest McCullough,* C. E.

The writer, having to construct for a contracting firm a septic tank and cinder filter bed, experienced difficulty in getting information about the cost of cinders. After a long correspondence he decided that filter beds constructed entirely of cinders are not so common in the United States as in England.

The majority of replies were to the effect that cinders were too expensive in comparison with sand to pay to use them. Some men did not see where cinders could be enough better than coarse sand to justify their use. But as the contract was taken the specifications had to be followed, and the experience obtained may be of value to others.

Cinders are not always readily obtainable. In large cities every manufacturing plant near railroad lines has its cinders taken care of without cost. It uses some, but the rest are taken by concrete contractors, railroads, pleasure parks, etc. If not near railroad tracks the cinders are only removed free at certain times of the year, and there is a constant demand. None to speak of are wasted. Having to secure some cinders once to put under sidewalks, half a dozen plants were approached by the writer before the cinders were finally obtained. The plant was at such a distance the team could only haul one load each day, the driver doing his own loading and unloading. Paying the team and driver $5 per day of ten hours, and having a high wagon body, with a capacity of 2¼ cu. yds. in the load, made the cinders costly. No charge was made for the material, so it was mainly a question of hauling.

In securing the cinders for the filter bed it was found to be largely a question of haul. The work was in a small town, with three railroad lines. Two of the roads had a joint round-house, with a cinder pit. One road took all the cinders one month, and the other road took the cinders the next month. We were unable to do business with the third road, and were allowed to take the cinders for one month from the joint round house of the first mentioned roads on condition that they had the right to stop us at any time the cinders were needed on the line. Under this arrangement we worked two weeks. A man was furnished by us to keep the pit clean, and we had a team hauling to the disposal plant. The amount obtained was in the neighborhood of two carloads per week. The man was paid $2 per ten-hour day and the team, with driver, $3.50. We obtained about four carloads at a total cost of $66, or $16.50 per car, delivered at the plant. At the end of two weeks cinders were needed on the line and we were stopped.

Nothing could be done with the other roads, so an attempt was made to secure cinders in a large manufacturing city. This was no easy task, but finally we succeeded in getting nine carloads. A charge of $6 per car was made for loading. The freight rate was 11 cts. per 100 lbs. The cinders were very poor. In fact, some of the carloads were mainly ashes, but we were given the cinders as a concession, and had to take them as they came. It unfortunately happened that the cars containing the most ashes came in a rainy period, and were evidently weighed after being wet. The lowest amount of freight paid was $39.12 on one car, and the highest amount was $70.13. The average on the nine cars was $54.78. The cars contained from 32 to 40 cu. yds. each.

The work was not completed the year it was started on account of the early snow and the setting in of winter. In the spring one of the railroads kindly gave us five carloads at a cost of $5 per car and a 7-ct. freight rate. The average freight bill per car was $30. The road which gave us the four cars the year before also permitted us to take some head-end cinders from the pit for the final layer. From the pit we obtained about 10 cu. yds. of head end cinders, setting up a screen at the pit and screening them by hand. The screening and hauling cost $8. This lot was the cheapest we obtained, considering the fineness of the material required.

The space at the disposal works in which to handle the cinders was very small. The switch was one to a lumber mill and the track was in poor condition. The ground was marshy and old forms used on a concrete storm sewer were placed on the ground to save the cinders. Two cars were

*Chicago, Ill.

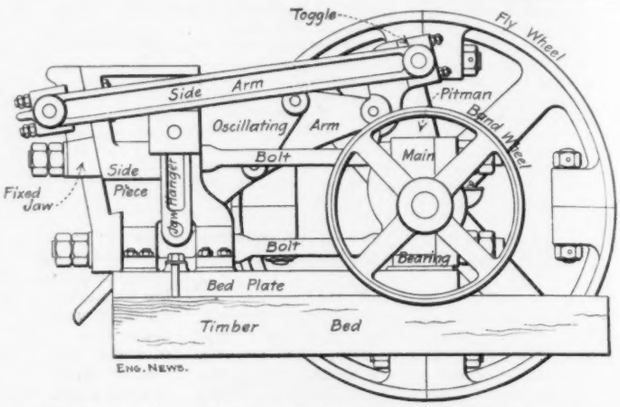



FIG. 1. AN ORE CRUSHER OF SECTIONAL CONSTRUCTION FOR MULE-BACK TRANSPORTATION.

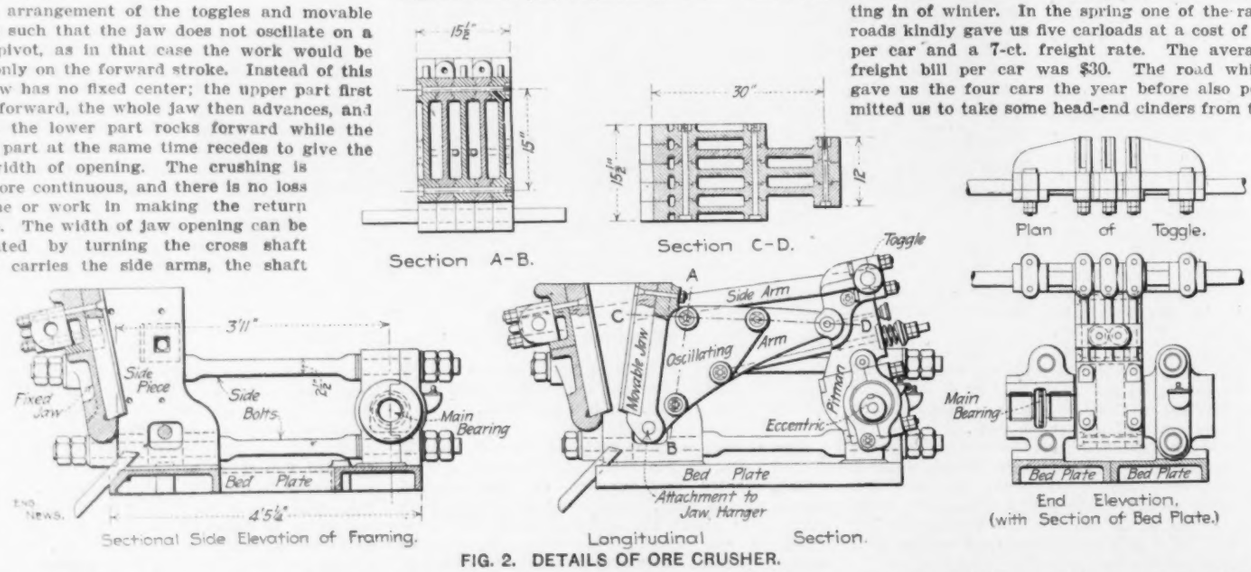



FIG. 2. DETAILS OF ORE CRUSHER.

unloaded by three men in about 3½ hours per car. This was simply shovelling it overboard to be afterward screened.

The specifications called for a depth of 27 ins. of cinders passing through a 1-in. screen and rejected on a ⅝-in.; then 9 ins. of cinders passing through a ⅜-in. screen and rejected on a ⅛-in. screen. We found when buying our screens that the wire cloth is made in meshes of a given number to the inch. To get the proper size aperture the thickness of the wire had to be taken into account. As, for instance, to get a ⅜-in. screen, we bought a 2½ mesh, with No. 19 wire. We took the galvanized wire, since it was connected by solder at each crossing of the mesh, thus preserving the aperture and also stood the exposure to weather well. The ordinary hardware grade wire cloth was amply stout enough in the various sizes. The eight-mesh screen was smaller than one with apertures of ⅛-in., but saved a lot of desirable material and passed all the dust.

One man passed 30 cu. yds. per day of ten hours over a one-mesh screen, and shoveled away the accumulated clinkers. But not all men were like him. It generally took two men to do that amount of work. If all the cars had come together, or if there had been a place to pile the cinders until all could be screened at one time, it would have paid to pile them up and put in a power screen. In passing them over the second screen they were screened twice, as the fine stuff was needed for the top layer. Scoops could not be used on second and third screens, as the cinders did not run down the screens fast enough. Square pointed shovels were used. One man could shovel on the first screen about 25 cu. yds. in ten hours. A second man then shoveled it on to the second screen, and a third man took it off the third screen and helped load the wheelbarrows. One man could do all the wheeling, having two wheelbarrows, one being filled while he was making a trip to the bed. If it rained and the cinders got wet, screening was stopped, for otherwise too much dust went on to the bed.

Of the 16 carloads first received two had to be rejected entirely on account of ashes, etc. A carload might be expected to yield about as follows: 10% large clinkers; 5% of material passing a ¾-in. opening and rejected on an eight-mesh screen; 10% of fine dust; 75% of material passing a 1-in. screen and rejected on a ⅜-in. screen.

The cinders broke down rapidly. A pile which had been passed twice over a screen of the size required, and had the dust taken from it, stood two weeks exposed to the weather, which was dry, and was then screened again on the same screen, when fully one-third passed through. Of this, about one-third was shown to be dust when passed over an eight-mesh screen.

The screens were 2 ft. wide and 6 ft. long. One end was elevated 4½ ft. A hopper, or rather a deflecting board, was nailed across at the top, and all the material thrown over the end at it, dropping to the screen. When screening rapidly over an eight-mesh screen, one man shoveled from the pile to the first screen. A boy with a scraper like a small wooden hoe worked the cinders on the screen and helped them to the bottom. A man stood there to shovel them into the wheelbarrows and keep the bottom clear. If the cinders were a little damp and seemed dusty two screens were used, this calling for another man and boy. At one time it was necessary to use three screens, as much of the cinders was in reality fine ashes. In this lot the percentage of waste in fine stuff was very large.

Toward the last there were several large piles of waste cinders and still the fine stuff was not half in the bed. An unsuccessful effort was made to secure front-end cinders from a railroad. A request for fine cinders to the manufacturing plant brought up a car of ashes. The writer had made a plan for an arastra to be worked by horse-power to grind up the cinders when he noticed a feed mill in a hardware store. This was purchased, and was found capable of grinding about ¾ cu. yd. of cinders per hour, of which fully half was dust too fine to use. As might be expected, the ground product was very hard and heavier than the fine cinders obtained in the ordinary manner. The team and driver cost $3.50 per ten-hour day. One horse was found to be unable to keep the pace all day. The driver did all the shoveling.

Trouble soon developed by reason of the iron in the cinders. After the machine had stopped and been taken apart several times, we decided to have a man pass all the cinders over a screen and watch for iron. Until such a searching examination is made it would be hard to believe how many washers, nuts, bolts, spikes and nails, together with pieces of grate bars, go into a car of ordinary cinders. But all the iron was not caught before going into the mill. Some which had been melted could not be detected until the mill caught it and refused to let go. One set of burrs was broken and an extra set obtained. A small piece of iron got in then and traveled round and round until the new burrs were so smooth that all the dust caked on them, and then the machine declined to deliver. It was found by wetting the cinders a little before putting them in the mill that there was a slight improvement,

Trestle for Telpher Line Along the River Bank.

and the occasional addition of a scoopful of coarse sand and extremely fine gravel helped a little. But the numerous pieces of iron found in the cinders compelled an abandonment of the mill. The writer regretted then that the arastra had not been made. There are, however, in the market forms of mills which would have worked all right.

The rest of the cinders were tamped out with the tampers used on some concrete work. This was nearly as cheap as the mill, but the men grew tired of it.

In order to obtain the cinders required it was necessary to purchase nearly double that amount. A large quantity was used for filling before grinding them up was thought of. If a rotary screen or a shaker had been used a little more fine stuff might have been saved. On another job the writer will rig up frames containing three screens almost level, working by eccentrics to jig the material. The apparatus can be placed alongside the track and worked with a team of horses. All the cinders can be shoveled from the car directly on to the coarse top screen, and the material sorted by sizes at once. If a pile is left on the ground, however, more than a week before using it should be given a final screening before depositing in the bed.

The ground cinders are infinitely superior for cinder beds to the screened cinders coming from the pits, as the former are very hard and will not break down so readily as the ordinary kind. But even the ground cinders will break down enough in a short time to give sufficient dust to fill the voids.

### SUMMARY OF COST.

So far as we could get any information as to their origin, the cinders obtained were from a semi-hard coal. The carloads containing a large proportion of ashes may have been either from hard coal with mechanical stokers or from cheap soft coal.

The cost figures are based on the material in place in the bed after the waste was thrown away. The cinders were thrown directly from the car to the ground, and the screens were moved along the cinder piles. A carload, as received, is assumed to average 32 cu. yds. Men were paid 15 cts. per hour, and boys were paid 7½ cts. per hour.

The cost for screening and wheeling the ⅜ to 1-in. material forming the lower two-thirds or 27 ins. in depth of the bed was as follows:

| | Per cu. yd. |
|---|---|
| Unloading | $0.055 |
| Coarse screening | 0.055 |
| Screening twice or second screening | 0.225 |
| Wheeling to bed | 0.075 |
| Total | $0.41 |

The cost of spreading is really included in the wheeling, as the men had time to spread the cinders between loads. The freight on this layer cost from $1 to $2 per cu. yd. of material actually placed in the bed*.

The final or top layer, varying from ⅛ to ⅜-in. in size, composed one-third the thickness of the bed, or was 9 ins. thick. The screenings which passed through the ⅜-in. mesh, from the cinders secured for the lower and coarser part of the bed, gave about one-third the total amount required. The remainder had to be obtained from material bought for that express purpose. The cost per cubic yard of screening and wheeling the first lot obtained varied as follows:

| | |
|---|---|
| Screened once when dry | $0.13 |
| Screened twice when slightly moist | 0.26 |
| Screened three times when moist and containing much dust and ashes | 0.39 |
| Wheeling | 0.075 |

On the remaining two-thirds of the fine stuff from the carloads last purchased, add the cost per yard of the two first screenings. The costs varied as follows:

| | |
|---|---|
| Screened once | $0.465 |
| Screened twice | 0.595 |
| Screened three times | 0.725 |

Spreading and leveling this fine stuff cost about 1 ct. per cu. yd.

Freight for the top layer of cinders varied from $1 to $2 per cu. yd. of material actually placed for all screened out from the lot secured for the bottom layer. On the last fine stuff, from cars where it was necessary to waste the material of over ⅜-in. in size, the freight was easily $10 to $15 per cu. yd. of material in place. The waste could not be sold, although a number of people were willing to haul it away if allowed to take it for nothing.

## A SINGLE-RAIL CONVEYING SYSTEM AT THE BAKER CHOCOLATE WORKS, MILTON, MASS.

In our issue of Feb. 7, 1901, we illustrated a telpherage system installed at the works of the Crocker-Wheeler Co., Ampere, N. J., in which a suspended cable was used as the track. The load was suspended from the trolley, to which the motors were attached, and the whole system was operated automatically.

We show herewith a system of conveying recently installed by the United Telpherage Co. at

*Unfortunately the author does not give the other unit costs for either layer, nor the figures from which they can be computed. In view of the peculiar circumstances under which the material was obtained final costs would be of little value for comparative purposes. Enough figures are given, however, to show that material suitable for filter beds might have been brought a great distance at a less unit cost to the contractor than was paid for unsuitable material.—Ed.

the works of the Walter Baker Chocolate Co., Milton, Mass., in which the cars are carried on an elevated beam supported by a trestle, and are hauled by a miniature electric motor-car, in which an operator sits. It is really, therefore, a single-rail suspended railway system.

The apparatus was installed for the purpose of conveying bags of cocoa beans received at the railway storehouse across the roofs of intervening buildings and over a river to the top story of a new mill. The total length of the line is about 500 ft. In this distance are included two 90° curves, one of 40 ft. and one of 20 ft. radius, and a steel bridge across the river, 55 ft. above the water.

The bags of cocoa beans weigh 300 lbs. each. The trucks in which they are carried have small wheels, so that they are easily rolled about on the storehouse or mill floors. Each truck can carry a load of 2,000 lbs. As the trucks are loaded, they are pushed underneath the overhead rail, and hooks are attached suspending them from trolleys on the rail. A train of three of these loaded trucks is attached to the electric locomotive, which hauls them over the line and delivers them in the mill storeroom. Here they are at once pushed out of the way, three empty trucks take their place and the return trip is made. The total time necessary for a round trip is only three minutes. The electric locomotive can attain a maximum speed of 1,200 ft. per minute, but the average speed on this very short line is 700 ft. per minute. The electric locomotive weighs 4,600 lbs., and the total weight of the loaded train with three trucks is 12,000 lbs. Speed is regulated by a controller similar to that on a trolley car, and brakes can be applied to all the wheels of the train. The locomotive takes its current supply by a short trolley pole from a line of wire strung over the tops of the cars.

The current used to operate the system is very small, and costs less than a dollar a day, and the one operator at $2 per day does all the work which formerly required several truckmen and teams. The accompanying cuts show at various points on the line the method of supporting the beam and rail on which the trucks run.

The whole plant was installed by the United Telpherage Co., of 20 Broad St., New York City, and we are indebted to that company for the information from which the above description has been prepared.

VIEW OF TELPHER TRAIN ON THE BRIDGE.

## OPEN WELLS AND TURBINE PUMPS.*

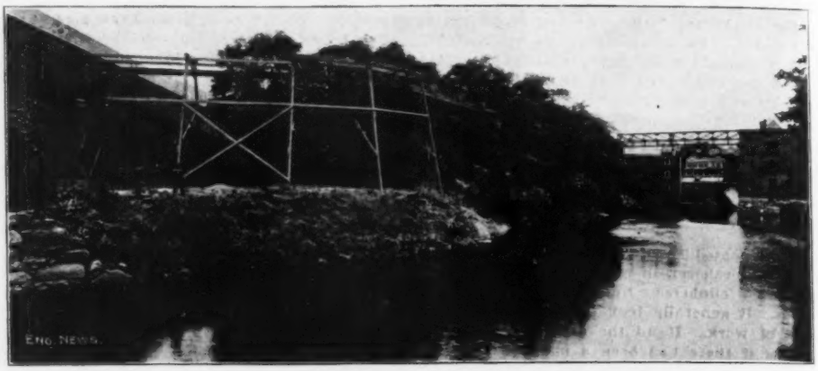
By Dabney H. Maury,† M. Am. Soc. C. E.

Fortunately the time is now past when, except amongst the ignorant and unprogressive, any hole in the ground is considered a well, and any device for lifting water, a suitable pump. And the absolute necessity for so co-ordinating the design of the well and of the pump that each may be best adapted for operation in connection with the other, and both with due regard for all the surrounding conditions, is now becoming more widely recognized.

So far as wells are concerned, this paper will discuss more particularly those which draw from water-bearing sands or gravel.

These wells may either be open wells or driven wells. An open well has hitherto been generally understood to be a well of a diameter so large that a man may enter it, which has its shoe or bottom edge in the water-bearing stratum, and which takes water from under the shoe. Driven wells are generally from 2 to 15 ins. in diameter, and, if they draw water from sand or gravel, they are usually provided with some sort of strainer or well point, designed to hold back the sand and gravel while admitting the water. These strainers act in one of two ways:

1. Their openings may be so fine as to exclude the finest sand to be found in the water-bearing stratum; or 2, the openings may be made considerably larger than the finer particles of the water-bearing stratum, but somewhat smaller than the coarser particles. This construction contemplates the drawing in of the finer particles through the openings, by any one of a number of methods, and the removal of these particles by repeated pumping, so as to ultimately form, outside of the metal strainer proper, a greatly enlarged strainer area, composed of the mass of the coarser gravel adjacent to the strainer.




GENERAL VIEW OF TELPHER CONVEYING SYSTEM AT WALTER BAKER CHOCOLATE WORKS, MILTON, MASS.

(The railway store house is in the foreground at the left. The new mill, on the third story of which the line terminates, is seen in the background, with a telpher train crossing the bridge.)

It is hardly necessary to say that the latter method of construction is the rational one, where there is any considerable proportion of even fairly coarse sand or gravel in the stratum. Where there are no coarse particles, good modern practice would still employ the strainer with large openings, as the necessary amount of coarser gravel may be dumped in, a little at a time, at the top of the well, rammed down and out at the bottom, the well being pulled back as far as necessary, and then re-driven through this gravel. When, by the repetition of this process of dumping in, ramming, pulling back, and re-driving, enough coarse gravel has been introduced to form a sufficiently large gravel strainer, the gravel remaining inside the pipe is finally removed with a sand bucket, the metal strainer is set, and the well is pulled back again to expose the strainer. Water is then pumped until the finer particles of sand and gravel cease to flow in, and the well is ready for service.

A well having a strainer composed of gravel, and of an area so large that the velocity of water flowing through its interstices shall not be great enough to draw in the finer particles of sand in the stratum, cannot clog up; and its useful life is limited only by the time required for the entire destruction of the metal shell of the strainer which holds the gravel back.

The use of any form of strainer which depends upon wire gauze or thin perforated metal to hold back the fine particles of sand, is, for many reasons, undesirable. Even while the strainer is new, the friction through the fine openings in the strainer and through the very small voids in the fine material which packs itself closely against its outer surface greatly reduces the yield of the well; and as corrosion clogs the openings the yield becomes still less. As this corrosion increases, the wire gauze or thin metal is destroyed in places, and the sand then flows in through the broken spots and fills the strainer.

Of the countless forms of strainer which are designed to hold back all the fine particles in the soil, the best that the writer has found is the old Cook strainer, familiar to every water-works man; but this also will, in time, corrode; and its capacity, even when new, can never equal that of a wrought iron pipe with punched or slotted openings from ½-in. to 1-in. in width and surrounded by a gravel strainer many times its area.

While many examples might be cited in support of the foregoing statements, the experience with certain wells designed by the writer some years ago will serve as fairly good illustrations.

In 1895, in order to increase the water supply of the Peoria Water Company, an open well of 11 ft. inside diameter was sunk by the pump-and-sink method, at a point 3,340 ft. north of the existing main well. In this well were installed two pumping units each consisting of a centrifugal pump having a vertical shaft, on the upper end of which a Pelton water wheel was set. A cast iron pipe conveys water at [illegible] lbs. per sq. in. from the force main of the main steam pumping plant, and this water is used to operate the Pelton wheel which drives the centrifugal pump. The water lifted by the centrifugal pump is discharged into a 24-in. tile pipe leading back

*Extracts from an illustrated lecture entitled "Some Recent Developments in Wells and Pumps" before the American Water-Works Association, at St. Louis, Mo., June, 1904.

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to the main well, and into this tile pipe the water used to run the motor is, after it has done its work, also discharged by gravity, and flows back to the main well with the pump water. An illustrated description of this hydraulic transmission system was published in Engineering News of Jan. 13, 1898 (p. 19).

It was the original intention to sink the 11-ft. well all the way to bed rock, seal its bottom, so as to make a water tight pump pit, and then drive out horizontally through the wall of the well a sufficient number of push wells, equipped with strainers, to admit to the suction pipes of the pumps as much water as the ground would readily yield. There was little or no gravel found in the water-bearing stratum, which was almost entirely composed of sand of medium coarseness.

The well sunk without difficulty, at an average rate of over two feet per day of ten hours, until within about 8 ft. of hardpan, at which point the rate of inflow of the water through the narrowing annular space between well shoe and bedrock became so great that the sand was dragged in as fast as it could be removed; and it was found impossible, with the appliances at hand, to sink the well more than one foot further, which brought it to within about 7 ft. of bedrock. An attempt to push down a steel cylinder 10 ft. in diameter, inside the well, had to be abandoned after much time and labor had been expended, with a gain of only 1 ft. more in depth.

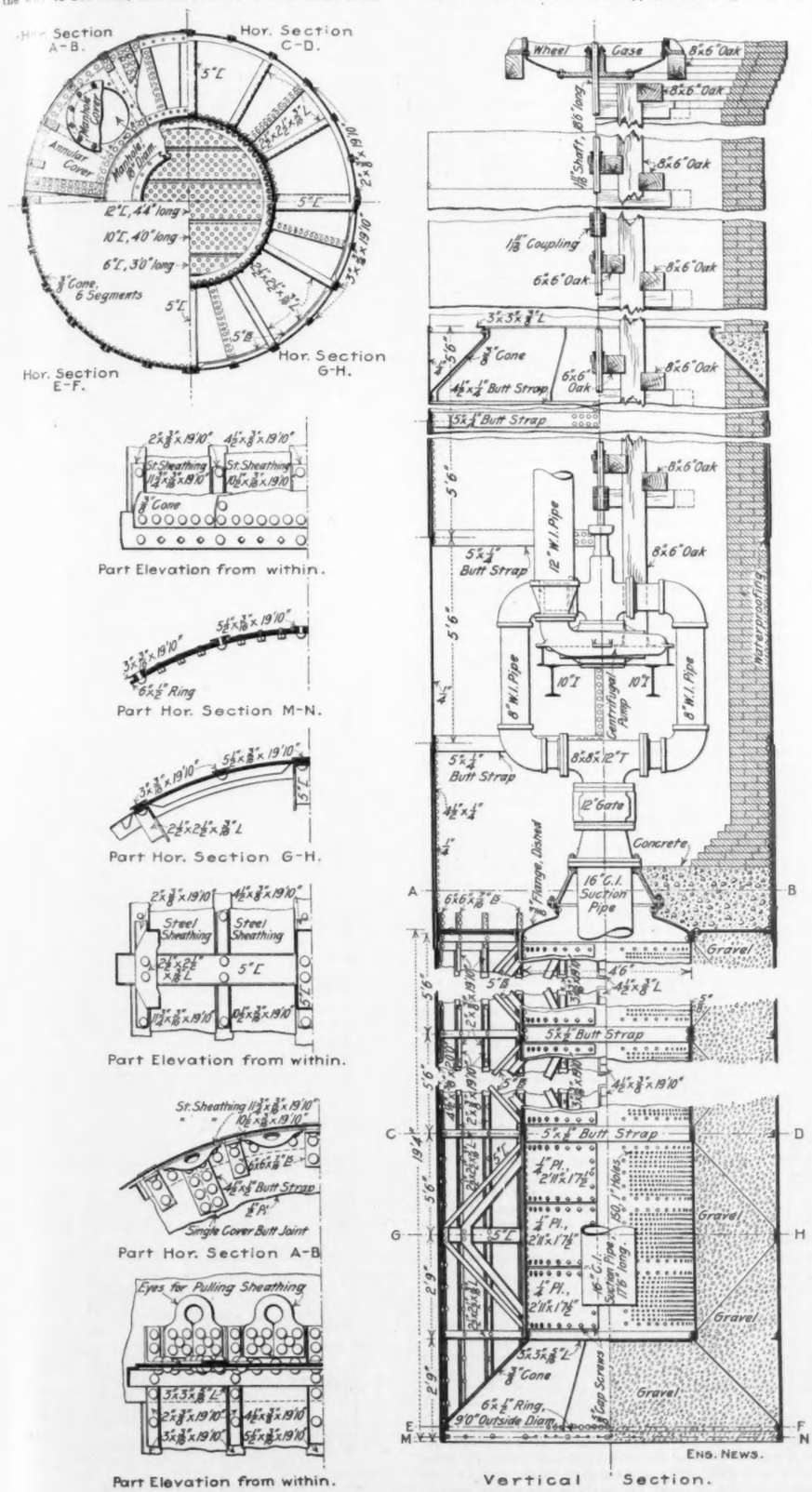



FIG. 1. OPEN WELL WITH SELF-CONTAINED GRAVEL STRAINER.
Designed by D. H. Maury, Peoria, Ill.

Four 6-in. wells were then driven to bedrock in the bottom of the well, and four more 6-in. wells were pushed out through openings in the wall of the well 12 ft. above bedrock to an average distance of about 8 ft. All these wells were fitted with Cook strainers and were connected to the suction pipes of the centrifugal pumps. The whole plant has been in very successful operation (whenever the low water conditions required its use) ever since; but the capacity of the well was somewhat disappointing, and tests made from time to time show that the head required to overcome the friction of flow of the water through the sand to the strainers, and through the strainers themselves, is, as our present better knowledge of the state of the art would lead us to expect, very great.

In 1899 it was found necessary to improve the main well of the Peoria Water Company in order to increase its capacity and to shorten the suction lift of the main steam pumping engines. The suction pipes of the main engines were shortened, and a steel tank was built around them, so that they should, at times of low water, draw from the tank instead of from the main well. Four wells were sunk down to bed rock inside the main well and close to its wall. Each well was a steel cylinder, elliptical in cross section, with diameters of 4 and 5 ft., and was sunk by the pneumatic process through 19 ft. of gravel.

Into each well, after it was sunk, was lowered a steel trussed frame, carrying at its lower end a centrifugal pump with its suction and discharge pipes, and at its upper end a Pelton water wheel connected to the extension of the vertical pump shaft. The motors are so connected as to be driven by water under pressure from the force main of the steam pumping engines, and the motor water, having done its work, flows into the tank, to be pumped over again by the main engines. The centrifugal pumps deliver their water into the tank through openings in its side. The result of all these changes is that the capacity of the well is increased at low water from 40 to 50%, while the suction lift of the main pumps is now not greater than about 12 ft. This plant was described in detail in an article in Engineering News of April 26, 1900 (p. 268). The article did not, however, relate the later experiences with the strainers on the four steel caissons or secondary wells.

The lower section of each caisson was, for a length of 4 ft., punched with ¾-in. holes, 70 holes to the square foot. Inside the shell of the caisson, and covering the inner surface of the punched portion, was a sheet of perforated copper, the holes in which were about 3-64-in. in diameter. This sheet was fastened to the outer shell by cap screws, copper wires being inserted between the copper sheet and the outer shell in order to give the necessary clearance. After the plant had been running for some little time, it was found that a head of about 15 ft. was required in order to force 1,250,000 gallons per day through each of the strainers. In order to see what was the matter the writer went down to the bottom of one of the caissons while the pump was running, inspected the strainer, and found that most of the small holes in it were completely closed. He then drove a drift pin through the copper sheet and through a ¾-in. hole in the outer steel plate, and worked the pin around in the gravel outside. As soon as the pin was withdrawn a ¾-in. stream of water spurted out with sufficient force to go entirely across the caisson. The water was at first discolored, but in a few seconds ran perfectly clear. More holes were then punched through the copper plate with the drift pin, and in a few minutes the water rose inside the caisson so fast that the writer had to climb out hastily.

All the copper sheets were ordered removed, and as each sheet was stripped off, the drift pin was used to work in the finer material in the gravel around the caisson. The next test made on one of the caissons showed that, with a head of about 8 ft. water was forced through its improved strainer at the rate of more than 4,000,000 gallons per twenty-four hours, and without dragging in sand.

The writer was not long afterwards called upon to design a well for a water-bearing stratum of considerable depth, the normal water level being close to the surface, and the stratum being composed almost entirely of sand, with little or no gravel. Realizing that it would be impossible to sink an open well by the pump-and-sink method to any very great depth, it was decided to sink the open well only as far as might prove, as the work progressed, economically practicable, then sink four 10-in. driven wells in the bottom, seal the bottom, and draw from the driven wells. The driven wells were to be equipped with strainers composed of 9-in. wrought iron

pipes, 20 ft. long, with slots about ¾-in. wide, and surrounded by a mass of gravel dumped in from the top as previously explained. This construction would have resulted in giving a dry pump-pit in which the pump would be set far below the normal water level—probably 35 ft.—and the capacity of the four 10-in. wells with properly prepared strainers would probably have been not less than 3 to 5,000,000 gallons per day. By the time the plans for this well were completed, however, the writer had devised another design for a well for the same conditions, which embodied so many advantages that it was preferred to the one just described.

This design contemplated a well of smaller diameter, but very much larger strainer area. The well can be sunk either by the pneumatic or pump-and-sink process; the strainer is of gravel; and the construction is such that the strainer is carried down with the well, being

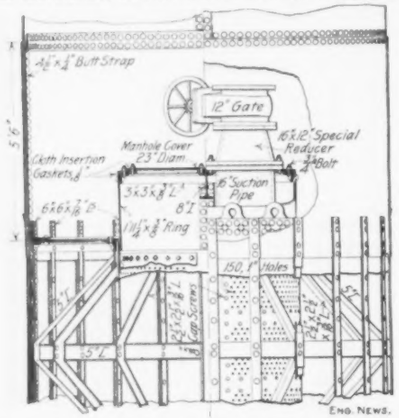



Fig. 2. Modified Detail of Well with Self-Contained Gravel Strainer.

closed against water and air pressure during the sinking, and afterwards uncovered so as to permit the inflow of water. The well was designed to be sunk 63.25 ft. in sand. It may be considered as divided into three sections: (1) the strainer section; (2) the intermediate section (built of thin steel, to be lined after sinking with masonry) and (3) the upper section, which is of masonry, and which also includes a small circular well house, above ground, to house the motor. Fig. 1 shows the construction of the well.

The strainer section is 9 ft. outside diameter and 19.25 ft. long. It consists of two cylinders, with an annular space, to be filled with gravel, between them. The two cylinders are joined at the top by a flat plate in six segments, each having a circular manhole to give access to the annular gravel strainer; and at the bottom, by a frustum of a cone, terminating in a cylindrical cutting edge. The two cylinders are also securely braced together throughout their whole length. The inner cylinder is of heavy steel, punched with a large number of 1-in. holes, arranged in rectangular groups, each group being closed, during sinking, by a steel plate with air-tight gasket. The outer cylinder is a skeleton built up of horizontal circular angles and channels connected by vertical guides, the guides being riveted to the rings in pairs, the outer guide in each pair being wider than, and overlapping, the inner guide. Between each two pairs of guides slides a loosely fitting steel sheathing plate, secured at its lower end, during sinking, to the cutting edge by cap screws which are removable from within. Each sheathing plate terminates just above the strainer section, and inside the intermediate section, in a strong steel forged eye. The outer and overlapping guides keep the sheathing plates from moving laterally. At the top of the inner cylinder is a flanged and dished steel head.

The intermediate chamber is a cylinder of ¼-in. steel, which at its lower edge overlaps the strainer by 6 ins. and is fastened thereto by angles and guide strips. At the upper end of the intermediate chamber is a frustum of a cone, which carries a flange for connecting to the bottom of the air shaft.

The outside diameter of the strainer section and of the intermediate section—9 ft.—is such that each of them can be built complete at any structural iron works, and then transported on a flat car to the site of the well.

The method of sinking the well, if the pneumatic process is used, is as follows: The strainer section is set up in place, and the annular space between its two cylinders is filled through the six manholes with washed and sized gravel, the larger stones—which may be 6 ins. in greatest diameter—being placed next to the inner cylinder. The size of the outer vertical layers of gravel is regulated by what the test borings have shown to be the nature of the water-bearing stratum. The manholes are closed, and the strainer section is sunk as far as may be easily possible by excavating the material from the inside. The intermediate section is next lifted by derrick and lowered until the holes in its lower edge come fair with those in the guide strips and angles at the top of the strainer, and the two sections are riveted together. Both sections then constitute a working chamber which is air and water-tight from top to bottom, except where the upper ends of the sheathing plates pass up, outside the strainer and inside the intermediate chamber. The leaks here may be closed by building a temporary annular brick wall a foot high on the flat plates just inside the eyes of the sheathing plates, and filling the space behind it with coal tar pitch. The top of the strainer section is loaded with pig iron, the air shaft and air lock are connected to the upper flange of the intermediate chamber, and the sinking is carried on by the pneumatic process.

As the top of the intermediate chamber sinks below the surface of the ground, a masonry wall is carried up. When the well has been sunk to the desired depth, the cap screws which fasten the sheathing plates to the cutting edge are removed and the bottom of the well is covered with clean and sized gravel. The steel plates which are bolted to the inner cylinder are next removed, course by course, beginning at the lowest, and the temporary wall, built to stop the leaks around the sheathing, is removed, and the sheathing plates are pulled up, one by one, inside the intermediate chamber. The two cast iron reducers, the section pipe, and the 12-in. gate, are then bolted in place, the bottom of the intermediate chamber is covered with concrete, and the masonry wall is built up high enough inside the chamber to prevent lifting of the concrete floor by the upward water pressure.

The air pressure may then be safely dispensed with and, the 12-in. gate having been closed, the air lock and air shaft are removed and the rest of the work is done in the open air.

This type of well, which is designed more particularly for use where there is practically no gravel in the water-bearing stratum, has the following advantages: (1) Its strainer, being composed of gravel, held back by very heavy steel, is practically indestructible. (2) The strainer cannot clog, for the gravel is finer in the outer than in the inner layers. (3) The capacity of the well is very great, the strainer area being so large that, assuming only 30% of voids in the gravel at its outer edge, the velocity of the inflowing water will, when the well is pumped at the rate of 5,000,000 gallons per 24 hours, be only 2 ft. per min., or one-thirtieth of a foot per second. This is not sufficient to move the finest sand in any stratum worth serious consideration as a source of water supply. (4) The pump is in a dry pit, always accessible for inspection and repairs, and is set below the normal ground water level, so that no priming is required. There are no joints in the suction pipe below the bulkhead. (5) The well may be readily sunk by the pneumatic process in locations, and to depths, which would render the sinking of an open well by any other process impossible. (6) The first cost is less than that of a well of any other type for use in sand, and of equal capacity.

The steel work for a later design for a well of the same type is shown, in part, in Fig 2. The improvement consists in the change in design of the head of the inner cylinder of the strainer, so as to provide a manhole to give access to the strainer, if desired. The points of difference from the earlier design are clearly shown by the drawing.

Fig. 3. shows the steel work for the strainer of a well now nearly completed for the Peoria Water-Works Co. In this case the water-bearing stratum is coarse sand and gravel, and the strainer consists of a cylinder of ⅝-in. steel, 9 ft. in diameter by 21 ft. 6 ins. long, and contains more than 34,000 11-16-in. holes. These holes are closed while the well is being sunk, by steel plates bolted to the inside of the cylinder. At the top of the strainer there is a frustum of a cone which serves as a foundation for the masonry wall of the upper part of the well, and which carries a smaller cylinder flanged at its upper end to bolt to the bottom of the air shaft. A removable steel bulkhead is also provided. This well may be sunk either by the pump-and-sink method or by compressed air. In either case the plates covering the strainer holes are removed after the well is sunk, and the finer particles of the water-bearing stratum are washed in with a hose having a nozzle small enough to enter one of the holes. These finer particles may then be pumped out. After all the plates have been taken off, and a gravel strainer formed outside of them, the watertight bulkhead is bolted on, and the suction pipe, reducer and gate are bolted in place. The gate being closed, the sinking plant may be removed, and the pump set up and connected.

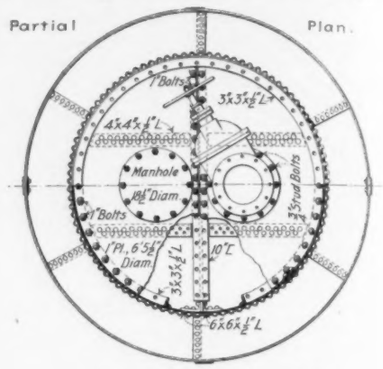
This well would have even a larger capacity than the one just previously described, for its gravel strainer would be considerably more than 9 ft. in diameter. It is simpler in construction and its cost is less. It would naturally be preferred wherever there is any appreciable amount of coarse gravel in the stratum.

## TURBINE PUMPS.

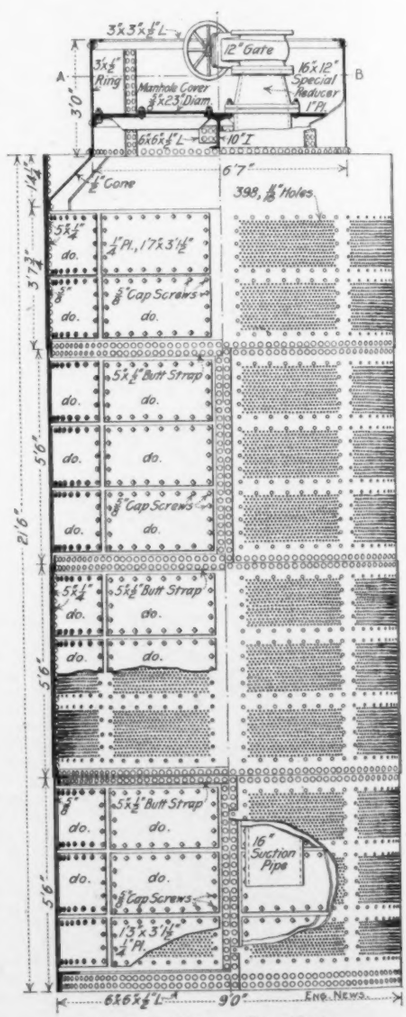
It will be noted that while any type of pump small enough to enter the pump pit may be used in connection with any of the last described types of wells, all these wells have been designed more particularly for use with pumps of what has been commonly known as the centrifugal type.

The writer has for years been impressed with the idea that there was a great deal of room for improvement [in] the much neglected so-called centrifugal pump, and that just as soon as these improvements were made the [pump] would come into far more general use. This idea is now being fully realized, and what the Patent Office calls "Pumps; Subclass, Rotary Single Piston," are at present being designed and built on more rational lines.

The principles governing the construction of a rotary single-piston pump should be exactly those governing the construction of a turbine, with due allowance for the fact that the pump, by its rotary motion, is to lift water, while the turbine is to be given a rotary motion by the fall of water from a higher to a lower level. In the turbine there are stationary guide blades through which the water is directed to the vanes of the moving wheel. Two essential conditions of a theoretically perfectly efficient turbine are that the water shall enter the guide




Horizontal Section A-B.




Vertical Section.

Fig. 3. Well in Coarse Sand Gravel, Peoria Water-Works Co., Peoria, Ill. D. H. Maury, Engineer.

blades without shock and leave the vanes of the wheel without whirling motion relatively to the earth. In a pump the water should be taken into the revolving wheel, or impeller, without shock, and discharged through the fixed guide blades without whirling motion relatively to the earth. In both turbine and pump the water passages should be as smooth and as uniform in size as possible, and they should be so constructed as to cause no abrupt changes in direction of the moving fluid. The more the pump depends on centrifugal action, the less efficient it will be; for the greater the centrifugal action, the more whirling motion there must be in the water leaving the pump.

A striking illustration of the losses due to this whirling motion was furnished by the behavior of two pumps tested by the writer about five years ago. The suction and discharge pipes of each pump were exactly like those of the other pump. For equal quantities of water pumped, the suction frictions, as shown by piezometer measurements, were the same, while the friction in the discharge pipe of pump No. 1, which depended more on centrifugal action for its work, was from three to four times as great as that in the discharge pipe of pump No. 2. Pump No. 2 was also, apart from the fact that it produced less friction in its discharge pipe, much more efficient than pump No. 1. The greater friction as shown by the piezometers in the discharge pipe of pump No. 1 was doubtless due to two causes: (1) The centrifugal force in the whirling water entering the base of the discharge pipe, exerted a fictitious and excessive pressure on the piezometer tube at that point; and (2) as the whirling water traveled upwards in its longer spiral path the friction was naturally greater than that caused by the water flowing with less whirling motion in pump No. 2.

It is the application of these principles, almost within the last year, to what has been but should no longer be called the "centrifugal" pump, that has resulted in developing it at last into a turbine pump, suitable for high lifts, and capable of relatively high efficiencies.

The essential parts of a pump of the rotary single-piston type are: the shaft; the rotary piston, or runner, or impeller, as it is variously called; the case surrounding the impeller, and the openings provided for the attachment of suction and discharge pipes to the case. The old style centrifugal pump had no guide blades for absorbing the wasted energy in the whirling water as it left the impeller. A properly designed modern pump has these guide blades and thus becomes practically a reversed turbine.

The impeller may either be of the open type, with vanes on one or both sides of the disk which carries them, or it may be of the hollow or closed form, the vanes being contained between two disks, one of which has a suction opening in its center. With either type the hydraulic pressures resulting from the motion of the impeller cause an end thrust which tends to force the disk towards the suction side of the pump. A number of devices for balancing this end thrust have been patented.

The advantages of the turbine pump are: (1) Small first cost. (2) Extreme simplicity; there is but one moving part, and that is in rotary motion. (3) Durability; the wearing parts are practically limited to the shaft and its bearings. (4) Compactness; a pump of 15 or 20 million gallons capacity can be set on a vertical shaft in a pump pit 7 ft. in diameter, which means a great saving in cost of foundations and setting. (5) Adaptability for connection to any type of driving engine or motor.

The efficiency of well designed turbine pumps ought to be as great as that of turbines of the same horse-power. The writer can see no reason why pump-makers, after they shall have had a little more experience with these new pumps, should not realize as high as 85% efficiency, and possibly, in exceptional cases, even more.

There are now several manufacturers who are prepared to build turbine pumps of almost any capacity, and for any lift up to 1,000 ft.

## THE SPONTANEOUS IGNITION OF COAL.

By Alfred O. Doane.*

When bituminous coal is stored in large quantities, a rise in the temperature of the mass almost always occurs. Under certain conditions and with some varieties of coal the temperature rise may be so great that the coal will ignite, frequently causing much damage and expense.

When coal is shipped to distant points in the holds of vessels the cargo is liable to take fire and many instances are on record where ships have been destroyed, sometimes with much loss of life. Fires in the bunkers of naval vessels and other steamships have also occurred.

For a long time, the cause of this heating was imperfectly understood, but as a result of investigations by several commissions and eminent chemists in different parts of the world, the origin of the trouble has been made clear.

Prof. Vivian B. Lewes, of the Royal Naval College, Greenwich, made a careful study of the subject, and his conclusions, which agree on most points with those of other investigators, show that the true cause of spontaneous heating is the condensation and absorption of oxygen by the coal in situations where the heat generated by this action cannot be radiated as fast as it is produced. As this oxidation is increased by heat, it follows that as the temperature of the coal rises the chemical activity rapidly increases, provided there is a sufficient supply of oxygen available, until the temperature of ignition is reached and the coal begins to burn.

The different kinds of coal vary greatly in their liability to heat. Anthracite coal does not heat at all. In the case of bituminous coals, those containing a large percentage of volatile combustible matter and considerable sulphur in the form of pyrites or sulphide of iron appear to have the greatest tendency to heat; there are, however, some semi-bituminous coals low in sulphur and ash, which heat badly. Almost any bituminous coal will heat if the conditions are favorable, as when freshly mined coal, containing a considerable amount of fine coal or dust, is stored in large quantities and high piles, or in bins so constructed that the heat is not readily dissipated when generated.

The presence of moisture has a marked effect, as it appears to increase the chemical activity of the absorbed oxygen and promotes the oxidation of the hydrocarbons present in the coal. If the coal contains iron pyrites in considerable quantity, the moisture assists in the decomposition of the pyrites; this is accompanied by an increase in volume, which breaks up the coal and exposes fresh surfaces greedy for oxygen.

It has been noticed that coal cargoes often ignite under the hatchways, where the coal has been broken up by dumping into the hold from a considerable height while loading. Similar conditions are produced where coal is dumped into bins from a high trestle, a practice which is very common. One of the difficulties encountered in burning powdered coal is the problem of storage of the powdered coal, as it has proved to be extremely liable to spontaneous ignition on account of its finely divided condition.

Fires in coal bins are apt to start next to a wall or partition where cracks or joints allow a small supply of air to enter, if at the same time the heat is prevented from radiating sufficiently. Fires are also liable to occur at the small pipes which are sometimes distributed in coal pockets with the idea of ventilating the coal, but which in most cases have done more harm than good.

Any system of ventilation to be effective would have to change the air throughout the mass of coal frequently enough to carry away all heat produced by chemical action; anything less than this would simply increase the danger by furnishing a supply of oxygen. With coal in large masses it is hardly practicable to adopt ventilation as a means of prevention.

Various tests have been proposed to determine in advance the liability of any given coal to heat. The gain in weight of a sample kept at a temperature of 250° F. for a definite time has been tried; also the test by the absorption of bromine. In most cases, small scale tests are not very valuable, as it is difficult in the first place to get a representative sample, and again it is commonly impossible to ascertain the history of the sample and to find out how much opportunity it has had to absorb oxygen.

The amount of moisture present in an air-dried sample of coal is an indication of its liability to heat, the danger increasing with the percentage of moisture contained. Coal containing over 4.75% after air-drying is said to be dangerous.

In order to reduce the danger from heating as much as possible, the following precautions should be observed. The storage bin should be roofed over. No wood should be used in its construction. The depth of the coal should be reduced as much as possible; it is better not to exceed 12 ft. All iron work used, including posts, should be protected by concrete; this protects from fire and acid water from the coal. It is well to have a circulation of air under the bottom and around the sides of the bin or pocket, as this will carry away considerable heat. Under no circumstances should any steam pipe or smoke flue be led through the bin or along the walls, and in general, every effort should be made to keep the coal as cool as possible. In a large Boston power plant there is a bin in the boiler room to supply the stokers, the temperature is very high above the boilers, and considerable trouble has been experienced from the heating of coal in this bin, while the same coal in a pocket outside gave no trouble, although stored in much greater depth and volume.

The Navy Department has just completed at the Boston navy yard a steel frame concrete coal pocket. It has a transverse section like an inverted capital M, with all its angles truncated; the sloping sides of the triangular-shaped bottom have about the same inclination as the outside of the coal pile, so that when filled the depth of the pile will be nearly equal in all parts at the same time. A very large radiating surface is exposed on top, bottom and sides, the bottom is fitted with numerous chutes and tracks run underneath so that coal cars may be filled from any part of the bin, which is also equipped with apparatus for unloading coal from vessels or railroad cars, and for supplying coal to warships.

As almost all coal will heat to some extent, it is desirable to know that the safe limit is not exceeded. For this purpose some large consumers of coal have pipes containing thermometers in various parts of the pile. These may be permanently attached to pillars or other parts of the structure, or may be made of ½-in. or ¾-in. pipe furnished with steel points. These pipes may be forced into the coal pile at suspected points, and a thermometer lowered and the temperature taken. Another and simpler way is to use ⅝-in. iron rods, which may be made in sections, and connected with screw couplings if desired. These are inserted in the coal at convenient places, and after remaining until they have reached the temperature of the surrounding coal are removed and tested by the hand. An experienced man can tell by the feeling when the coal is dangerously hot, and by measuring to the hottest portion of the rod the depth of the heated portion of the pile below the surface may be found. If the temperature of any part of the pile is above 140° F., it is time to take active measures to prevent further heating. When coal in the interior of a coal pile ignites, the heat cokes a layer of coal about the glowing nucleus. For this reason it is difficult to quench the fire by playing water on the surface of the pile as the coke forms a roof which sheds water. This difficulty is avoided by driving a pointed 2-in. pipe having the lower 3 or 4 ft. perforated with ⅜-in. diameter holes into the pile at the point where it is on fire, and to the depth indicated by the small test rod. The upper end of the pipe is then connected to a hose and water is forced into the heart of the fire, which is quickly quenched, if of limited area, and with the minimum amount of water.

There is, of course, some danger of the coal heating again, especially if a considerable body of coal has been moistened, but it will probably be several weeks before this happens, and the operation is easily repeated or that portion of the coal may be used first.

The most common procedure, and one that is generally effectual, is to shovel over the pile which is heating, or in case of a coal pocket fitted with bottom or side outlets and coal handling machinery, the coal may be run out at the bottom, hoisted up and dumped on top, thus giving the coal a chance to absorb oxygen and cool off.

This operation, especially if done by hand, is very expensive, as well as laborious, disagreeable, and sometimes dangerous on account of the presence of gases from the heated coal.

## TREATMENT OF A RESERVOIR OF THE BUTTE WATER CO. WITH COPPER SULPHATE.

By Eugene Carroll,* M. Am. Soc. C. E.

In 1892, the Butte City Water Co., predecessors of the Butte Water Co., began the construction of a large impounding reservoir about 13 miles south of Butte, Mont., on a mountain stream having its

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*Chief Engineer and Superintendent Butte Water Co., Butte, Mont.

source in the summit of the Rocky Mountains. The plans called for a masonry dam 120 ft. high, with its crest at an elevation of 6,000 ft. above sea level.

During the summer of 1893, the dam being only partially constructed and then impounding about 40,000,000 gallons of water, the stored water became unfit for domestic use on account of the disagreeable odor and taste.

In 1894, the dam was increased in height to an elevation of 5,960, giving a reservoir capacity of 180,000,000 gallons of water. The same trouble

Fig. 1. Photo-micrographs of Anabaena from Reservoir of Butte Water Co., July, 1904.

(The upper view shows the organism on a larger scale than the lower one.)

was experienced during this summer as the previous year, and further work was stopped on the dam until some remedy could be discovered.

Extensive study of the conditions to discover the cause and find a remedy, if possible, for the trouble was made. In these investigations, Mr. Emil Starz, Ph. G., a chemist and bacteriologist of Helena, Mont., was retained to assist. In addition to Mr. Starz, consultations were had with bacteriologists of note in all parts of the country, and it was finally decided to increase the water supply flowing into the reservoir, and to more thoroughly clean the bottom of all surface soil and soil which contained vegetable organisms.

Notwithstanding our efforts in this line, necessitating a large expenditure of money, the water in 1897 was so infected with anabaena and asterionella as to be absolutely nauseating in odor and taste. It became so offensive that the odor was continually present in the city, caused from the water being used on the streets by the sprinkling carts.

The company then proceeded to secure additional water supplies, going to a very large expenditure of money in bringing in water from the Big Hole River, a distance of 32 miles from the city, and requiring the pumping of about one-half our water supply to a height of 840 ft. This new supply enabled us to cut out the reservoir during the summer months.*

(*Articles on the construction of the dam forming this reservoir were published in Engineering News for Dec. 15 and 22, 1892; Aug. 17, 1893, and Sept. 5, 1895. The last two articles named were written by Mr. Carroll. Two paragraphs in the latest of the articles named are particularly interesting just now. They read as follows:

"Owing to the fact that so much new ground was flooded during the present season, and that there was not sufficient water to give the reservoir a top overflow after construction closed, the water has become stagnant, having a bad taste and smell. The writer thought that by placing air compressors upon a boat and moving the same from place to place over the surface, he could sufficiently agitate the water to prevent this stagnation. Before the boat was completed, however, the water had become so badly spoiled that it was deemed impracticable and the project was abandoned."

"A recurrence of this trouble is not expected, as during the spring months the water supply is largely in excess of the daily consumption."

As is shown by the present article, the expectation expressed in last of the foregoing paragraphs was not realized.—Ed.)

Noticing the article in Engineering News of May 26, 1904, on "Preventing the Growth of Algae in Water Supplies," correspondence was opened with Dr. G. T. Moore, of the Department of Agriculture, with a view of treating our Basin Creek Reservoir and eliminating the vegetable organisms in that body of water. After some correspondence and investigations, the reservoir was treated, under the advice of Dr. Moore, as is described in this article.

The Basin Creek reservoir has two forks; one extending about three-fourths mile in a southerly direction and the other about one-half mile in a southwesterly direction. Distribution of the copper sulphate was started at 2 p. m. on July 7, using three boats. One boat distributed in the southern fork, another in the southwestern fork and the third boat in the main body of the reservoir in front of the dam. The quantity used was 1 lb. of copper sulphate per 1,000,000 gallons of water, thus requiring 180 lbs. of sulphate. One boat distributed 40 lbs. in one hour in the short arm. The second boat distributed 60 lbs. in one hour and ten minutes in the main body of the reservoir around the dam, and the third boat distributed 80 lbs. in the long arm of the reservoir in one hour and fifty minutes. In each boat two men were used—one to row and one to hold the gunny sack containing the sulphate over the stern of the boat.

There was a heavy wind blowing down-stream, which made it extremely difficult to row, but the boats were kept in continual motion from the time the copper sulphate was dropped into the water until it had entirely dissolved.

During the first ten minutes of the distribution of the sulphate, nothing peculiar could be noticed in the water, but after 15 minutes fine light green threads began to float in it, growing steadily in number, until in about 35 minutes after starting there had formed a yellowish green scum over the entire surface of the reservoir. The phenomenon was similar to the formation of a very flocculent precipitate.

In about two hours the scum assumed a dark green color, the borders turning slightly brown. At that time, a sample of the water was taken and carefully examined and a small trace of copper was shown by the experiment. Samples of the scum were also examined and found to contain 11¼% of metallic copper, showing that a large amount of the copper was taken up by the anabaena and other organisms and thereby removed from the water.

During the first 24 hours the water in the reservoir exhaled a more pronounced and disagreeable grassy odor than before treatment. Its color at the end of the first 24 hours was a decidedly dirty green, with comparatively little scum floating on the surface, and upon testing 1,000 cu. cm. of the water for copper, at this time, a very faint reaction was obtained. The sulphates in the water were slightly higher and the odor was considerably less.

At the end of the second and third days, very slight changes were noticed in the color and taste of the top water, but it was greatly improved in taste, color and smell below 20 ft. in depth.

At the end of the fourth day, a continued improvement was noticed in the taste, color and odor, and at the end of the fifth day there was a very decided change for the better in color: the water assuming a natural color and only a slight odor and taste being noticeable on the surface. At 20 ft. below the surface, at the end of the fifth day, the water was tasteless and odorless, and of a bright, natural color. Very slight changes for the better were noticed on the seventh, eighth and ninth days, and on the tenth day the water apparently had assumed its normal condition.

Microscopical examinations of the water, however, during this period, as shown in the appended tables, revealed the fact that there were a few spores of the anabaena left in the water, and that the asterionella had begun to increase again.

Owing to these conditions, it was deemed advisable to give the reservoir a second treatment of the copper sulphate, and on the morning of July 19, twelve days after the first treatment, a second treatment was given in exactly the same manner and with the same quantity as the first treatment.

After the second treatment very little change was noticed in the water on the surface of the reservoir and hardly any scum formed. Twenty-four hours after the second treatment, the water showed a very decided improvement in color, with absolutely no taste or odor. On the third day after the second treatment, as shown by the analyses in the tables, the water was in an absolutely normal condition and entirely free from the vegetable organisms which had given us so much trouble in the past.

During the progress of these treatments, the reservoir was entirely cut out from the city supply and no flow through it was permitted, the overflow being closed and the water allowed to slowly rise. With the exception of occasionally opening the overflow to remove the scum which had blown down against the dam, and an occasional opening of the blow-off pipe, there was no current running through the reservoir during the period.

On Sunday, July 24, the water in the reservoir being absolutely pure, for the first time in ten years, during the month of July, it was turned on to the city mains.

The accompanying views, Figs. 1 and 2, are reproduced from photo-micrographs of anabaena and asterionella, respectively, found in the reservoir.

The accompanying tabulated results are taken from the report of Mr. Emil Starz, Ph. G., of

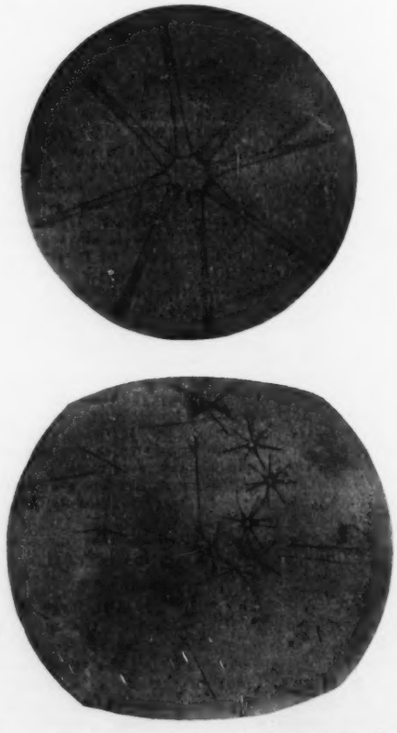


Fig. 2. Photo-micrographs of Asterionella from Reservoir of the Butte Water Co., June and July, 1904.

(The lower view shows a group of organisms and the upper view a single organism on a larger scale. The group was photographed in June and the single organism in July.)

Helena, Mont., who assisted in the treatment of the water, and who made the analyses and microscopical examinations.

From the experience in the treatment of this reservoir, Mr. Starz deduces the following conclusions:

(1) If anabaena is the only source of trouble, a

TABLE I.—Analyses of Water Taken 10 ft. Below the Surface of the Basin Creek Reservoir Before and After Treatment with Copper Sulphate.

| Parts per 100,000 of Water. | | | |
|---|---|---|---|
| Date, 1894 | June 16. | July 12. | July 22. |
| Taste | Slight | Grassy | None |
| Odor, cold | Faint | Musty | None |
| Odor, warm | Musty | Grassy | None |
| Appearance | Turbid | Clear | Clear |
| Total solids | 8.5 | 10.5 | 9.0 |
| Loss on ignition | 2.5 | 4.3 | 4.0 |
| Fixed mineral | 6.0 | 6.2 | 5.0 |
| Chlorine | 0.25 | 0.29 | 0.42 |
| Oxygen consumed | 0.45 | 0.58 | 0.65 |
| Nitrogen as nitrites | 0 | 0 | 0 |
| Nitrogen as nitrates | 0 | 0 | Traces |
| Ammonia, free | 0.00558 | 0.014 | 0.0024 |
| Ammonia, albuminoid | 0.0039 | 0.0048 | 0.0098 |
| Reaction | Neutral | Neutral | Neutral |
| Sulphates | 3.08 | 1.02 | 0.85 |
| Total hardness | 2.25 | 2.5 | 2.2 |
| Copper | 0 | 0 | 0 |

very small amount of copper sulphate (one part in 8,000,000) is sufficient to eradicate the pest.

(2) The best results are obtained by treating the water supply before the anabaena has ma-

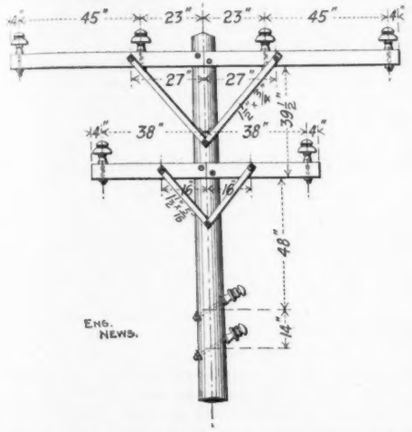



Fig. 1. Experimental Medium-Span Construction, Edison Electric Co. of Los Angeles, Cal.

tured and formed into filaments, as recommended by Messrs. Moore and Kellerman in their bulletin No. 64, U. S. Department of Labor, Bureau of Plant Industry.

(3) The copper practically disappears from the water after 24 hours, and no traces are found after 48 hours from treatment.

(4) If there is a mixed growth of anabaena and asterionella, a somewhat stronger application of sulphate gives better results, or a second treatment following the first in a short interval will accomplish the same.

(5) The copper sulphate treatment of water supplies is harmless, cheap and very effective.

(6) No fish are killed from an application of 1 part in 8,000,000.

(7) The time consumed for the treatment is so short that it will not interfere with supplying the public with water during the purification process.

The cost of the treatment of the reservoir, exclusive of the superintendent and bacteriologist who directed the operations, was as follows:

| | |
|---|---|
| 360 lbs. copper sulphate at 9½ cts. per lb. | $34.20 |
| 6 laborers, 4 hours each, at 30 cts. per hour | 7.20 |
| Total cost | $41.40 |

This is equivalent to 23 cts. per 1,000,000 gallons. This expense would be cut down were another treatment made, as only one man to a boat is really necessary.

TABLE II.—Microscopical Examinations of Water from the Basin Creek Reservoir Before and After Treatment with Copper Sulphate.

| Number of Organisms per 1 cu. cm. of Water. | | | |
|---|---|---|---|
| Date, 1904. | Anabaena Spores. | Anabaena Developed. | Asterionella. |
| Before treatment: | | | |
| June 24 | 27 | 4 | 256 |
| July 2 | .... | 380 | 520 |
| July 7 | .... | 1,408 | 600 |
| One day after treatment: | | | |
| July 8 | .... | 18 | 39 |
| Before second treatment: | | | |
| July 12 | .... | 3 | 56 |
| July 19 | A few | 0 | 132 |
| July 20 | 0 | 0 | 135 |
| After second treatment: | | | |
| July 22 | 0 | 0 | 160 |
| July 24 | 0 | 0 | 25 |

## MEDIUM-SPAN LINE CONSTRUCTION.*

By C. A. Copeland,† Assoc. Am. Inst. Elec. E.

In the past it has been the chief desire of electrical companies to get to the customer with some sort of a line and obtain a swift revenue, while the engineer has not considered it worth his while to spend more than a wisp of his time on line work. The result has been that more than 75% of the troubles experienced in the distribution of power, both as to number and cost, have occurred outside the central and sub stations. The major part of the cost of these troubles has been due to lack of confidence in electricity as a power fund and convenience which does not always show on the books. These remarks apply as well to telephone and telegraph lines and distributing systems as those for light and power.

Not only have lines been excessively troublesome, but they have cost too much. With a view to eliminating both of these faults on cross-country lines, the Edison Electric Co. of Los Angeles has been experimenting on several special methods of distributing-system design. The one immediately concerned may be termed medium-span cross-country construction.

The ordinary length of spans, say from 120 to 140 ft., which have been used for the lines, have evidently been transplanted from early days and from localities where snow and ice load the wires to their breaking point even with 100-ft. spans. The conditions obtaining around a newly contemplated line should be as carefully studied as those surrounding the hydraulic and central station installations. Transplanted engineering may not always thrive in new soil.

The conditions encountered in the valley districts of Southern California are: (1) No snow and ice; (2) a temperature ranging from 20° F. at night in winter to 140° in the sun in the summer (that is, a wire will become that hot); (3) occasional severe dry north summer winds which blow hay and mustard stalks upon the lines; (4) frequent interference with lines by wild cats, buzzards, sandhill cranes, mudhens and owls—especially the May and June owls; (5) numerous and almost unavoidable hedges of eucalyptus trees from 50 to 150 ft. tall, which, with the assistance of winds, shed twigs and long shreds of bark on to the lines; (6) rapid decay of poles, some rotting off in four years, while the average life is eight; (7) high cost of poles, the cheapest being cedar, and in 35 and 40-ft. lengths costing from $5 to $10 in the yard.

Experience with bare aluminum cable suggested to the writer that stranded copper cables might be used in long span construction. It was proposed to take good stocky 40-ft. cedar poles, space them 225 ft. apart, space the wires 45 ins. apart, and employ a sag of from 15 to 24 ins., depending on the installation temperature. It was designed that a three-phase construction for a voltage as high as 40,000, with one or two circuits of Nos. 3, 4, 5 and 6 cable with single cross-arms, and Nos. 0, 1 and 2 with double cross-arms, should be used.

The longest continuous long-span work previously employed was in Europe on the Paderno-Milan transmission, with solid No. 1 wire and steel lattice work poles spaced 190 ft. In the light of subsequent experience it would seem that if stranded wire had been used the poles could have been made a little heavier and taller and spaced twice as far apart. On the Vizzola-Ticino-Milan transmission, also, steel latticed poles about the same distance apart had been used.

These ideas were received with temerity. It was argued that in case a wire broke, so and so would happen. But if stranded and carefully installed they will not break. It was also argued that in case the poles rotted the line would be weakened more than if the poles were nearer together. But it would seem that a line should be kept in good repair, whether the poles were many or few, either by letting down 5 ft. or stubbing. An engineer would not buy a boiler with more tubes in it than necessary and let them get in poor repair because there were enough tubes left to keep the boiler safe.

It was argued that in case the top of a pole burned off at the brace, as sometimes happens on the 30,000-volt line, No. 6 wire would not support the weight on a 450-ft. span. Accordingly, two experimental spans of 250 ft. were constructed and strung with bare solid "second-hand" medium hard drawn copper, and while it is not necessary to go into great detail in regard to this test, it is sufficient to say that it was amazing the abuse these wires stood before breaking. No. 6 aluminum cable was also tested, and stretched so far before breaking that it also deserves much respect. The stretching factor of safety of copper wire is scarcely appreciated by engineers, and after these tests the writer very nearly recommended solid wire for 225-ft. spans. In fact, a European steel pole line employs 246-ft. spans with solid No. 2 and 00 wires on 40-ft. poles.

The writer knows of no case where a good solid medium hard-drawn wire has broken without a good apparent excuse, such as a burn-off. He has known of such breaks on poor wire which did not come up to the company's standard specifications. The moral is, that with rigid specifications followed by tests, much longer spans with solid copper can be made. We have eight miles of No. 5 line with 150-ft. spans, with wire which did not stand a very good test, which has given no trouble.

Stranded copper, however, is superior for 225-ft. span work in that: (1) A careless lineman in nicking it reduces its strength less than by nicking a solid wire. A test was made on one cable during which one strand broke at a 5-in. sag on 225 ft., but the cable still stood up. (2) Its strength is more uniform throughout its length and therefor a less sag can be safely depended upon. (3) It has a higher strength per square inch because the wires are smaller and are individually stronger. (4) It has a spring effect or untwisting factor of safety. (5) It has a higher elastic limit.

It is believed (but not proven) that stranded copper will not burn off so easily as solid wire on account of its radiating facilities, and because one or two strands will hold the cable intact if the other strands burn off. It costs from 8 to 12% more than solid wire of the same conductivity.

Following out these considerations, four miles of experimental line were installed in two sections, one in the Lytle Creek district, near San Bernardino, two miles long, of three-strand No. 5 copper, and the other at Anaheim, of No. 5 seven-strand copper. In the former a 500-ft. span was inserted. Otherwise the constructions are identical, and have stood over a year and have passed through the most severe wind storms known in this section for many years. The poles and corner pins now stand perfectly straight, although another new line near by with 140-ft. spans and six wires leans badly from the wind. These medium-span lines were, of course, installed with care and by trusty men who have been with the company for several years.

The top cross-arm (Fig. 1) with three cables only; No. 13 Locke oak pins with a bolt center; 2¼-in. washers under each pin and nut; ordinary deep-groove double-porcelain insulators (selected) with a piece of copper wire netting under each to prevent the burning of pins; three strands of No. 17 medium hard drawn copper wires twisted together for a telephone cable which was strung on transposition glass insulators and No. 13 Locke pins, and transposed every third pole, were some of the features of construction. Mogul paint was used on all threads, nuts and points of contact of iron and wood and in the gains, and galvanized iron wrapped around the poles under the guy wires. The strand was not allowed to touch the ground and was spliced by twisting with an annealed and flattened copper tube. A double lock tie of No. 8 wire was used with a wood-covered tie wrench; no pliers or come-alongs were allowed on the job. All kinks were eliminated with a splice.

They are both 10,000-volt lines, and the advisability of using deep-groove double-petticoat insulators will be questioned. Seven years actual service, however, has shown them just as good as any. In fact, there are indications that they are better. They seem to discharge the

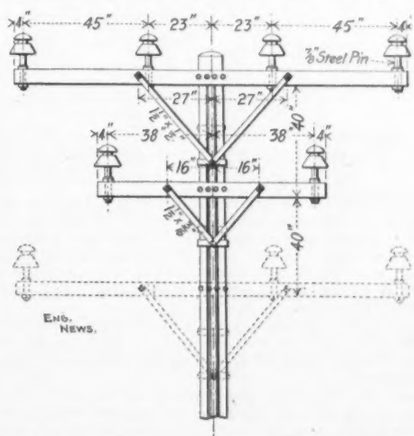



Fig. 2. Steel-Pole Construction for 300-Ft. Span.

line without burning the pins. Mechanically speaking, they are superior because the wire is let down closer to the cross-arm. They should, however, be used with caution because the conditions on other systems and localities might not be similar.

The following are representative specifications used for stranded copper cables:

1. This copper cable is to be used for long-span work with 225 to 300-ft. span. The cable must be bare and composed of seven medium hard drawn copper wires. The cable must have a resistance of .3944 ohms per 1,000 ft.; that is, equivalent to No. 6 of 100% Matthiessen's standard conductivity.

2. The cable must have a lay not greater than 4 ins.; that is, one turn of each wire around the cable in 4 ins. of its length.

3. The cables are to be furnished in such lengths that

*A paper read before the Pacific Coast Electric Transmission Association, Monterey, Cal., June, 1904.

†Edison Electric Co., 845 Coronado St., Los Angeles, Cal.

no splicing of individual strands is necessary. When the length of one wire in the strand runs out, the whole cable is to be cut at this point by the manufacturer, to be eventually spliced by means of copper sleeves when the line is constructed.

4. The cable must be pulled through a non-corroding grease bath before being reeled to prevent the chafing of the cable against itself in shipment. Paraffine is suggested.

The strength of the cable must be such that it can be pulled up to a 5-in. sag on a 225-ft. span. (To be strung with a 15 to 24-in. sag on the actual line.) In accepting the cable, seven samples will be tested from various portions of the shipment and five must stand a 5-in. sag, while two will be allowed to break at this sag. Twenty-five samples of individual strands will be taken from the shipment and given a twisting test, twisted six times on and off its own diameter. In such a test the strands must show absolute uniformity of material and drawing. The surface of these individual strands must present a good luster and be free from seams, drawing nicks and slivers.

5. Bids are solicited on this cable, manufacturers to specify weight per foot and price per foot.

The writer lays great stress on the old twisting test, as it is found to be an extremely good gage of uniformity of the product. It is not considered advisable to have a wire of 70,000, 50,000, 30,000, 65,000, 40,000 lbs. per sq. in. ultimate strength at various points along its length. It is more advisable to have it uniformly from 45,000 to 50,000. The twisting test determines this, and in a rough way the tensile strength.

Tests on the seven-strand Anaheim cable and the three-strand telephone cable showed an ultimate strength of 59,500 lbs. per sq. in., corresponding to a 5-in. sag on 225 ft. An actual span was used for the test and remarkably uniform results were obtained, the cable breaking at just 5-ins. sag each time. At 5½-ins. sag the cable had stretched 11 ins. in 225 ft., and had a permanent set of 4.6 ins. Subsequent cables have broken uniformly at 63,250 lbs. per sq. in.

After all, the important factor of this work is, has the engineer "done for a dollar what any fool can do for two," which brings us up to a consideration of comparative costs.

At the time when this matter was first being discussed, 5¼ miles of 30,000-volt line was built from Mentone to the new Mill Creek No. 3 power house. The ground was exceedingly rocky, which made the cost of digging holes from $1.50 to $3.50 each, and the cost of stringing and hauling very great, with two three-phase circuits of No. 4 wire, and 125 and 120-ft. spans. A saving of 16% could have been effected by 225-ft. medium span construction with cables, and the line would have been safer because the wires would have been 45 ins. apart instead of 36 ins. With No. 6 the saving would have been 21%, while with No. 3 wire, which is about the practical limit of this kind of work, a saving of 11% would have been obtained.

There is now being constructed 9½ miles or more of medium-span line in Lytle Creek, near San Bernardino, directly in the path of the severe north winds, of the 40-ft., wood pole, 225-ft. span construction, with deep groove double porcelain insulators on 10,000 volts. Half of it is to be strung with No. 5 and half with No. 6 cables, and a saving of 24¼% and 26½% will be effected. This is a single circuit line prepared for drawing in another one eventually. In single circuit lines where wire is a smaller percentage of cost the greatest percentage of saving by the longer spans is secured.

The company is now building 14 miles of line from Los Angeles to Inglewood to connect the old United Electric Gas & Power Company's beach town, 38 miles, 17,300-volt transmission system, which the Edison Electric Co. has lately acquired, with the 30,000-volt Edison system. This is composed of six No. 4 seven-strand copper power wires (see Fig. 2) strung on a new special porcelain insulator and the three-strand telephone cable mentioned above. Thirty thousand volts will be impressed on the line. The 40-ft. poles are of steel and placed 300 ft. apart. The cross-arms are of wood because of the danger of birds burning wires off by grounding, but special iron pins have been designed, and all pins are to be grounded together by a fine wire underneath the cross-arm to prevent burning of the wooden parts. The soil is mostly sand, and a cylinder of cement 5 ft. deep is used to set the poles in. Even then the cost is only $48 per mile more than a wood pole line with 125-ft. spans, because wood poles would have to be taller than 40 ft. If, however, 45-ft. wood poles and 225-ft. spans had been used, the cost would mean an advantage of 20% over an ordinary 125-ft. span cedar pole line.

The cost of a 40-ft. tripartite pole made by the Franklin Rolling Mill, of Franklin, Pa., in this steel construction, is about $35 f. o. b. Los Angeles, as against $9 for a 45-ft. cedar pole, so that the above figures are rather surprising. The excess cost of the 300-ft. span steel line over the 225-ft. span wood line is what the company pays in first cost to prevent depreciation. The advantage is gained that, should the line ever be changed or moved, the poles would be as good as new for a new place. Ordinarily, in such cases, even though the poles are not rotted badly, they are not worth placing again without sawing off. This principle, which is often lost sight of, is especially applicable to city distributing systems.

It will be observed that this construction is especially advisable on lines with small wires, i. e., telegraph, telephone and power lines of Nos. 3, 4, 5 and 6 wire. The percentage saving on single circuit lines is especially great, and the percentage saving is greater the greater the cost of poles and digging holes, and particularly where the poles must be hauled a great distance and when the company must provide tents and eating facilities along the line in building. On high voltage lines, where the insulators cost considerably, the saving is very patent.

Perhaps the principal mechanical, and therefore ultimate monetary, advantage in medium or long span work is the greatly reduced trouble with insulators and pins, and burning off of poles, and in fact all the troubles which lines are heir to, by making the parts fewer and each better, which, by the way, greatly reduces the necessity for double-pole lines. In other words, make good porcelain eggs and make them larger and stronger than are usually laid, put them in one good strong basket, and watch the basket, and it will not cost so much to watch the basket, either, as it usually does.

It will often be found, especially in this Western country, that, by building a line quickly, not only is money saved in construction, but revenue and profit is more quickly obtained or lost power more promptly eliminated. Medium span wood pole lines are built in 60% of the time usually employed on short-span lines.

Medium-span construction would seem advisable also for long distance telephone and telegraph work in certain sections, and where it is presupposed that a first-class line of long life, and of no trouble while it lives, is the more economical one in the end.

Only in rare instances does the 15 to 20 ins. sag instead of 8 make any difference in the height of poles. Private telephone lines should be at least 5 ft. below the lowest power cross-arm, and at least 8 ft. above the tallest trees, which usually dictates the height of poles. These methods may become important in case a double-pole line is considered advisable where small amounts of power are transmitted at high pressure or small distances.

The question of the preservation of poles from decay is of some importance in this discussion. Granting that a good, cheap, practical method of preserving poles at from 75 cents to $1 per pole can be found—and we are making rapid progress in this direction—the saving by using this medium-span construction is greater than cited above, and entirely removes the question of the greater weakening of the line by the decaying of poles in the longer span construction.

In conclusion, it may be said that by effecting a saving of from 10 to 30% in lines ordinarily costing from $700 to $1,700 per mile, and having from three to twelve of the smaller sizes of wire, a slight advance has been made in the art, in the field of light construction, where the cost of poles, freight and haulage is great, especially as they are better and safer lines than are ordinarily built with more cost, or stating it another way, they are as cheap as the cheapest allowable lines and twice as safe and free from trouble and danger.

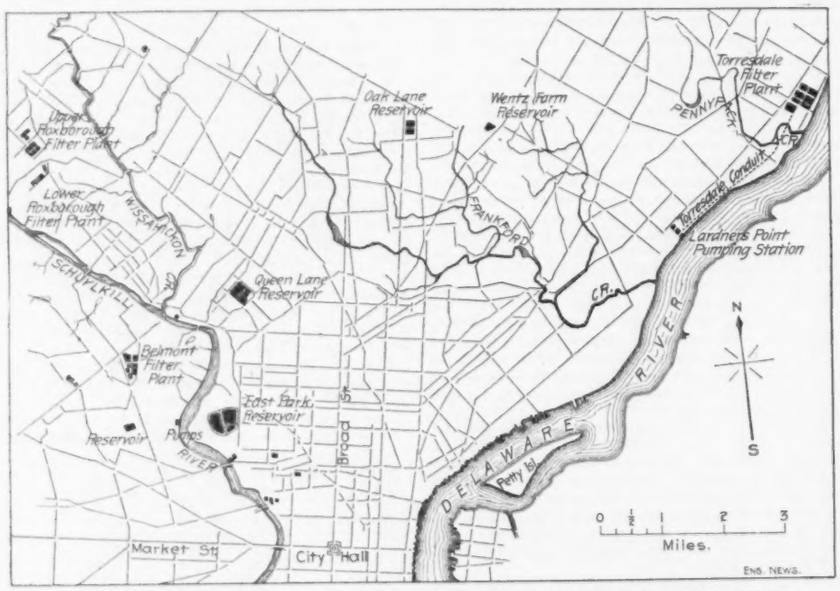



FIG. 1. SKETCH MAP OF PORTION OF PHILADELPHIA, SHOWING LOCATION OF FILTER PLANTS.

## THE PHILADELPHIA FILTRATION SYSTEM.

### General Description.

By far the largest filtration system in the world has been under construction for several years past at Philadelphia. Of the four independent plants being built one alone, known as the Torresdale Plant, will have a capacity of 248,000,000 gallons, while the Belmont Plant will have a capacity of 65,000,000 gallons, and the Upper Roxborough and Lower Roxborough plants have capacities, respectively, of 20,000,000 gallons and 12,000,000 gallons. These figures make a total capacity for the system of 345,000,000 gallons. Without entering into questions of high or low water consumption, and merely to show by comparison the immense capacity of the filtration system of Philadelphia, whether measured by totals or on the per capita basis, it may be noted that the average daily amount of water supplied by the eight water companies serving Greater London was 254,000,000 gallons in 1902. Of this supply 214,000,000 gallons passed through the total filtering area of 153 acres in use at the time. The per capita water consumption of the 6,373,748 people served by these eight companies averaged a little under 40 U. S. gallons in 1902, as compared with 229 gallons in the same year for Philadelphia with an estimated population of 1,350,000. Assuming that the American city, by the use of meters or other means, reduces the water consumption and waste to an average of 150 gallons per capita per day, the amount named in the experts' report mentioned below, the 345,000,000 gallons of filter capacity would supply a population of 2,300,000, if ample clear water storage were provided.

### HISTORY AND PRELIMINARY WORK.

The installation of this vast filtration system is the outcome of years of agitation for deliverance from one of the foulest water supplies of the world, as evidenced at times by a mere visual examination of the water, and as indicated continuously by the high typhoid mortality of the city. Schemes and counter-schemes for an improved water supply were proposed through a long period of years; some provided for filtration and others for a gravity supply from distant sources, but nothing was accomplished until the year 1899, when Mr. Samuel H. Ashbridge, then mayor of Philadelphia, appointed a commission of experts to report on the whole question of improving and extending the water supply of the city. This commission consisted of Messrs. Rudolph Hering, of New York, Joseph M. Wilson, of Philadelphia, and Samuel M. Gray, of Providence, R. I.; all members of the American Society of Civil Engineers.

The commission was instructed to work in conjunction with Mr. William C. Haddock, then Director of Public Works; Mr. John C. Trautwine, Jr., Assoc. M. Am. Soc. C. E., then Chief of the Bureau of Water and Mr. George S. Webster, M. Am. Soc. C. E., then and now Chief Engineer of

the Bureau of Surveys. The commission was required to make great haste in the preparation of its report, which was submitted on Sept. 21, 1899.*

The commission recommended the continued use of the Delaware and Schuylkill rivers, from intakes within the city, as sources of supply, utilizing as much as feasible of the present reservoir and pumping system, but extending the reservoir system so as to give at least 24 hours of sedimentation; slow sand filtration in covered filters for all but a small portion of the supply, mechanical filters to be provided at some of the stations where not enough land was available for slow sand filters; and covered reservoirs for filtered water equal to one-half day's supply of water.

The commission assumed that 150 gallons per capita per day would be ample, and based its estimate on a supply of 200,000,000 gallons a day for immediate construction, to supply an estimated population of 1,300,000 (actual population by census 1900, 1,293,697) and 450,000,000 gallons at the same per capita rate, in 1950. It found that the city was then taking about 95% of its supply from the Skuylkill River and 5% from the Delaware River (in 1902 these relative figures had changed to 90% and 10%, respectively), and advised that the safe limit of draft from the Schuylkill be considered as 150,000,000 gallons. This would require 50,000,000 gallons daily from the Delaware with future additions to be drawn from that stream.

Very soon after the report just outlined was submitted, preliminary studies for the improvements recommended were begun under the direction of Mr. Haddock and Mr. Webster, already named. One of the first things to be done was to establish an experimental purification plant at or near the Spring Garden pumping station on the Schuylkill River.† Experimental work was started at this plant on Sept. 5, 1900, and was continued until the present year when the plant was removed to the site of the Belmont filters and work there resumed. On Oct. 29, 1901, experiments on the treatment of the Delaware River water were begun and continued until Sept. 1, 1903, when the station at the site of the Torresdale Filter was abandoned.

On Feb. 12, 1900, Mr. John W. Hill, M. Am. Soc. C. E., then of Cincinnati, O., was engaged as consulting engineer for the whole projected improvements, and on Jan. 1, 1901, as consulting engineer, he was placed in entire charge of the preparation of all plans and of the construction work. By ordinance of the Councils approved June 18, 1902, the Bureau of Filtration was formed and the staff heretofore engaged on the work being constructed in connection with the improvement, extension and filtration of the water supply, was transferred to this Bureau with Mr. Hill as Chief Engineer.

The work finally intrusted to Mr. Hill, as the foregoing statements imply, involves a virtual remodeling of the water-works of Philadelphia, beyond the network of the pipe distribution system, but even including some of the main feeders of the latter. To prosecute this work there was appropriated by ordinance on June 17 and July 12, 1898, $500,000; on Jan. 12, 1900, $3,200,000; on March 23, 1900, $12,000,000; on June 30, 1902, $1,300,000; on Dec. 29, 1902, $500,000, and on Dec. 18, 1903, $5,000,000, making a total authorized expenditure to date of $22,500,000.

Naturally, some modifications of the plans recommended by the commission of experts have been made as the studies progressed. The chief of these have been: (1) A filter plant with a daily capacity of 248,000,000 gallons at Torresdale on the Delaware River instead of 50,000,000 gallons; a tunnel conduit of 300,000,000 gallons daily capacity or more from these filters to Lardner's Point and an immense new pumping station at the Point, instead of abandoning the old station here and placing a 50,000,000 gallon station at or near Torresdale. (2) Partly as a consequence of the change just noted, the omission of the proposed small mechanical filter stations. (3) The use of preliminary or roughing filters at the Belmont and the Lower Roxborough slow sand filtration plants, thus giving double filtration for the major portion of the water to be taken from the Schuylkill River under the present contracts. The water delivered to the Upper Roxborough filters has a longer period of sedimentation than that passing through the filters at Lower Roxborough. Eventually, preliminary or roughing filters will be installed at Torresdale (Delaware River) instead of adding to the area of slow sand filters now being provided. (4) The installation of meters has been deferred and the works are being built to the capacity of the present enormous per capita consumption. If meters or other effective measures for waste prevention are introduced, it appears to be calculated that the reduction in per capita demand thus effected will offset the increase in population and legitimate use, so the works now being built will require only relatively small additions, as noted in the opening paragraph, to meet the needs of the city until 1950. This change, as regards meters, will lead to the ultimate use of the full safe yield of the Schuylkill as estimated by the experts; but for some time to come the relative percentages of water taken from the Schuylkill and the Delaware will be far different than now prevail (90% and 10%, respectively). Ultimately, 150,000,000 gallons daily will be drawn from the Schuylkill and about 250,000,000 gallons from the Delaware, or 37.5% and 62.5%, respectively.

Having broadly outlined the history and present status of the purification works and other improvements to the water supply of Philadelphia, we will next give some general particulars of the four filter plants now in use or under construction. The location of these plants is shown by the sketch map, Fig. 1, which includes the city of Philadelphia north of Market St. Considering the map, it will be seen that in the western part of the city, and taking water from the Schuylkill River, there are the Belmont Plant and the Upper and Lower Roxborough plants, and in the eastern and northern part there are the Torresdale filters and conduit and the large new pumping station at Lardner's Point. About midway of the city, on a line drawn from the Torresdale to the Upper Roxborough filters, there is the 70,000,000-gallon distributing and compensating reservoir known as the Oak Lane Reservoir. Roughly, the Belmont plant will supply the high areas and a limited low district in the western part of the city in which dwells about one-eighth of the population, while the Torresdale plant will supply the remaining and greater part of the city's area. Itemized, the works include therefore the separate filter plants at Belmont, Upper Roxborough, Lower Roxborough, and Torresdale, the Oak Lane Reservoir, the Torresdale Conduit and the Lardner's Point pumping station. These various items will be considered separately.

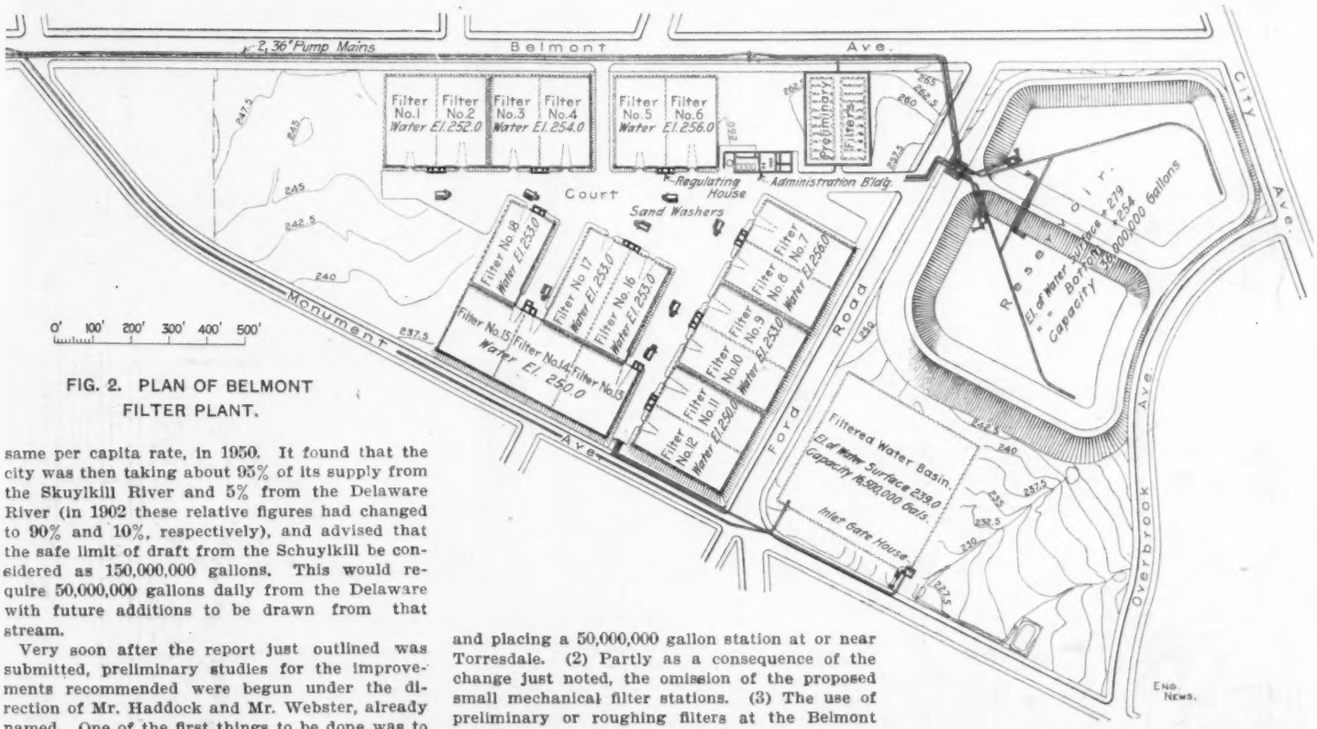



FIG. 2. PLAN OF BELMONT FILTER PLANT.

BELMONT FILTERS.

The Belmont filter plant, located on Belmont Ave. near its junction with City Ave., and west of Fairmount Park, is the second in size of the four plants. It comprises two subsiding basins, each containing at flow line 36,000,000 gallons of water which, at the present rate of consumption, represents 2.4 days' sedimentation; a system of preliminary filters adapted at a rate of 80,000,000 gallons per acre to deal with 40,000,000 gallons of water daily; 18 plain sand filters; a clear water basin with a capacity of 16,500,000 gallons; eight hopper sand washers; and an administration building and pumping and power station. The relative locations and areas occupied by these chief features of the plant are shown by Fig. 2.

SEDIMENTATION RESERVOIR.—The sedimentation reservoir consists of two divisions 25 ft. deep at water level and 29 ft. deep at top of embankment. The walls of the basins are earth embankments with side slopes of 1 on 2 and a width on top of 18 ft. The areas of the two divisions are as follows:

| Division. | Flow line. | Floor line. |
|---|---|---|
| East | 5.43 acres | 5.47 acres |
| West | 5.33 acres | 5.037 acres |

*A lengthy abstract of the report, accompanied by diagrams showing the growth of population and water consumption in Philadelphia and other cities and the effect of meters in reducing consumption in a number of cities, and also by tables showing the relative costs of constructing and maintaining the various filtration and other water supply projects considered, was published in Engineering News of Oct. 5, 1899.

†This plant was illustrated in our issue of March 29, 1900.

Referring to the plan, Fig. 2, it will be noted that the arrangement of the influent and effluent pipes is such that the raw water may be delivered entirely in one division and drawn from the other; or may be delivered into and drawn from each division at the same time; or one basin can be cut out of service entirely; or either influent may discharge into either division or both divisions, and likewise the subsided water can be directed into either of the two effluents. Normally the mode of operation is as follows: The raw water enters the east division through a pipe laid along the bottom and terminating in the northeast corner in a number of tees. It then rises from the bottom to the top of the east division and is drawn from the surface by a floating pipe at the northwest corner which discharges into a pipe along the bottom of the west division. This last pipe discharges through a number of tees at the northwest corner of the west division. The water then rises to the top and is withdrawn by a floating pipe at the southeast corner into the effluent to the preliminary filters. It will thus be seen that during the period of continuous subsidence in the reservoirs the raw water passes from end to end and from bottom to top of each division of the reservoir before it is drawn to the filters. The possible alternative courses of flow have already been indicated. To provide for them there are in the gate house to the reservoir eleven 48-in. diameter Ludlow stop valves operated from a floor above. All effluent and influent pipes are 48 ins. in diameter, and the supply pipes from the pumping station at the river bank are 36 ins. in diameter.

PRELIMINARY FILTERS.—The purpose of the preliminary filters at Belmont, and, indeed, at the other plants where they are installed, is threefold: (1) They enable the plain sand filters to operate at a higher rate than would be possible with raw water, and thus reduce the necessary acreage of filter beds; (2) they increase the yield of the plain sand filters between cleanings from 60,000,000 or 70,000,000 gallons to 90,000,000 or 150,000,000 gallons per acre; (3) they maintain a more regular effluent from the sand filters. The preliminary filters at Belmont will have a capacity of 40,000,000 gallons per day, and room is reserved for additions which will increase the capacity to 95,000,000 gallons per day. Their location is clearly shown by the plan, Fig. 2, and they consist of 20 concrete tanks, each 60 ft. long, 20 ft. wide, and 8½ ft. deep. In the bottom of each tank is first placed 12 ins. of 2½-in. to ¼-in. gravel and above this is a 30-in. layer of coarse sand that will pass a No. 6 sieve and remain on a No. 30 sieve.

Water from the subsiding reservoir enters the preliminary filter at the top; connections with the pumping mains on Belmont Ave. also permit raw water to be delivered to the filters if for any reason the reservoir is out of commission. The passage of the water through the filter material is very rapid as will be seen if we note that each 60 × 20-ft. tank delivers 2,200,000 gallons per day, or at the rate of 80,000,000 per acre. The filtered water runs to a main collector at the center of the filter and thence through a main to the conduits leading to the slow sand filters.

At the level of the gravel underdrains is placed a system of wash pipes consisting of two lines of 12-in. main pipe from each of which 2-in. branch pipes placed on 8-in. centers extend right and left to the opposite main pipe and the side walls of the tank. The main and branch pipes are perforated on the upper sides, so that water forced into them under 50-ft. head surges up through the filter material and passes into overflow troughs and thence into a waste conduit. As will be seen, the method of washing is substantially the same as for mechanical filters, except that the effluent and the wash pipes are separate. When complete washing of the sand is required, the mode of procedure will be as follows: One tank containing only the gravel will always be out of service, so that when another tank requires washing the sand from it is thrown out by an ejector, washed and returned to the idle tank. The washing thus proceeds from tank to tank, and except when actually washing, 19 of the 20 tanks will always be in service. No mechanical agitators are used for the reason that the engineers found by experiment that with the most efficient agitation a reverse current of water could not thoroughly clean the sand.

PLAIN SAND FILTERS.—The Belmont plant has 18 plain sand filter beds. These beds, owing to the shape of the area available for their location, could not be made of standard length and width, but they have about the same effective sand area. The horizontal dimensions of the eighteen beds are as follows:

| | Length. | Width. |
|---|---|---|
| Seven filters..... | 242 ft. 2 ins. | 135 ft. 5 ins. |
| Eight filters..... | 272 ft. 8 ins. | 120 ft. 2 ins. |
| Three filters..... | 196 ft. 5 ins. | 165 ft. 11 ins. |

The contour of the land was also such as to make it impracticable without costly excavation and fill to locate all the beds at the same elevation. A terraced arrangement was, therefore, adopted, as indicated by the elevations inscribed on the plan, Fig. 2. This arrangement involved a loss of head of 3 ft. between the sedimentation reservoir and the clear water basin.

Each filter is a rectangular tank with bottom, sides and roof of concrete and a net area at sand line of 0.735 acre. The roof is covered with 2 ft. of earth and gravel, dressed with top soil and seeded. In the center of each filter at the bottom is placed a main water collector, into which at intervals of 15 ft. are connected the right and left lateral collectors. The pipe system comprises an influent pipe to supply water to the filters, an effluent pipe to conduct away filtered water, a refill pipe to refill filters from below with filtered water after scraping the sand bed, a drain pipe to draw off the water from below the sand bed and conduct it to the sewer, a raw water drain pipe to draw off the water from above the sand line, a high-pressure pipe to supply water to the sand ejectors and sand washers, and a sewer to take the waste and storm water from all parts of the plant.

With the exception of two filters, the regulator

FIG. 3. PLAN OF UPPER ROXBOROUGH FILTER PLANT.

houses are designed to serve each two filters. The well or chamber under the regulator house is divided into a middle dry chamber and two side wet chambers. In the middle chamber are placed the pipes, stop valves and castings, which connect the main influent and high pressure pipes with the filters, the raw water drain to remove the water from above the sand line and the main effluent pipes which originate in the two wet chambers and are brought together into a tee at the center of the dry chamber. In the wet chambers are placed the effluent pipes, drain pipes to remove the water from below the sand bed, and the refill pipe.

CLEAR WATER BASIN.—The clear water basin which receives the effluent from the filter beds is 396 ft. long and 382 ft. 2 ins. wide, and has a depth of water of 15 ft. 10 ins. It has a concrete floor, side walls and roof, and in general is constructed exactly like the filters, except, of course, for the piping. From the clear water basin the water flows to the present rising pipes from the Belmont pumping station to the George's Hill Reservoir.

ADMINISTRATION BUILDING.—The administration building contains on its ground floor a boiler and pump room and offices, and on its second floor a laboratory for the examination of water samples. In the pump room are placed two centrifugal pumps, each of 5,000,000 gallons daily capacity, to supply subsided water to the preliminary filters for washing, and, if desired, to draw off the water from the low level filters. There are also three high pressure pumps for supplying water to the sand ejectors and sand washers, and two engines and generators for supplying electricity for lighting. Four 200-HP. marine boilers supply steam for air purposes. All parts of the plant, including the insides of the filters, will be lighted by electricity.

UPPER ROXBOROUGH FILTERS.

The filter plant at Upper Roxborough is the third in size of the four plants which comprise the Philadelphia filtration system. It includes the Upper Roxborough Reservoir, built in 1893, which is used as a sedimentation reservoir, a series of eight slow sand filter beds, a clear water basin and various subsidiary structures. The plan, Fig. 3, shows the arrangement of the various parts of the plant. The location is on a level plateau, so that the filter beds are all at one level, and not terraced, as at the Belmont Plant; the beds are also uniform in size, being 140 ft. 8 ins. wide and 219 ft. 10 ins. wide, with an area at sand level of 0.7 acre. They are constructed substantially the same as are the beds at Belmont, and the regulator houses, one for each pair of beds, are also of the same construction. The clear water basin is of the same construction as that at Belmont, and it has a capacity of 8,000,000 gallons. The existing Upper Roxborough reservoir, which was transformed into a sedimentation reservoir, consists of two basins, with an aggregate capacity of 147,000,000 gallons, which provides from seven to ten days' subsidence. This reservoir being 5 ft. lower than the filters, it is necessary to pump the water to the filters. For this purpose a set of three 18-in. centrifugal pumps, direct-operated by vertical compound condensing engines, was installed in the existing auxiliary pumping station at Lower Roxborough, about 3,000 ft. distant. These pumps receive water from the reservoir under a head of from 45 ft. to 65 ft. and deliver it to the filters against a head of 70 ft. The raw Schuylkill water is delivered to the reservoir from the Shawmont Pumping Station. Provision is made for the addition of nine or ten more beds to the plant when the occasion for them arises.

Two 65 HP. gasoline engines and triplex pumps supply water under 80 lbs. pressure to the sand ejectors and washers.

LOWER ROXBOROUGH FILTERS.

The smallest of the four filter plants is that located at Lower Roxborough, only about 3,000 ft. from the Upper Roxborough Plant, but at about 80 ft. lower level. The plan of these filters is shown by Fig. 4. They consist of a sedimentation reservoir, a preliminary filter and five slow sand filters, with a clear water basin. The five filter beds are arranged at different levels, as are those at Belmont, each filter being 2 ft. 9 ins. lower than the preceding, beginning at No. 5. Each bed is 109 ft. wide and 219 ft. 10 ins. long, and has an area of 0.537 acre, and there is a separate regulating house for each. The construction of the filter beds and of the clear water reservoir is the same as that of the corresponding parts of the Belmont Plant. The clear water basin has a capacity of 3,000,000 gallons, and the sedimentation reservoir, which is the old Lower Roxborough storage reservoir converted, has a capacity of 12,800,000 gallons. The raw water comes from the Shawmont Pumping Station on the Schuylkill River.

The Lower Roxborough Plant, like that at Belmont, has a preliminary filter. This consists of eleven concrete tanks 16 ft. wide, 64 ft. long and 5½ ft. deep. Each tank contains, first, a 5-in. layer of coarse gravel, then a 10-in. layer of 1½-in. to ¾-in. screened furnace slag, then a 24-in. layer of ¾-in. to ¼-in. screened furnace slag, and finally a 9-in. layer of compressed sponge. The raw water enters the filter at the bottom, passes upward through the filter bed and is drawn off at the top and delivered to the slow sand filters.

TORRESDALE FILTERS.

The Torresdale filter plant is located on the west bank of the Delaware River, north of Pennypack Creek, and is the largest of the four plants and the largest filter plant in the world. At present the work of construction embraces 65 filter beds, each having an area of 0.75 acre, and there is available land for 70 additional beds. The total capacity of the Torresdale works, based on 65 filters, with preliminary filtration of water, will be 248,000,000 gallons. The clear water basin has a capacity of 50,000,000 gallons, and from it the filtered water is delivered through the Torresdale Conduit to a pumping station at Lardner's Point, and thence to the distribution system. The plan, Fig. 5, shows the layout of the plant.

Generally speaking, the filter beds, the regulating chambers and the clear water reservoir are of the same construction as the corresponding parts of the Belmont plant. The principal exceptions are a number of reinforced concrete conduits and reinforced filter bed floors for nine or ten beds, located on filled ground. Of the 55 filter beds, 22 are 133 ft. 2 ins. × 253 ft. 2 ins., and 43 are 140 ft. 8 ins. × 235 ft. 8 ins. As will be seen, the beds are arranged in five banks of eleven beds each, with intermediate courts for sand washing and storage. The filtered water basin is 15 ft. deep and 601 ft. 10 ins. × 762 ft. 2 ins. inside dimensions.

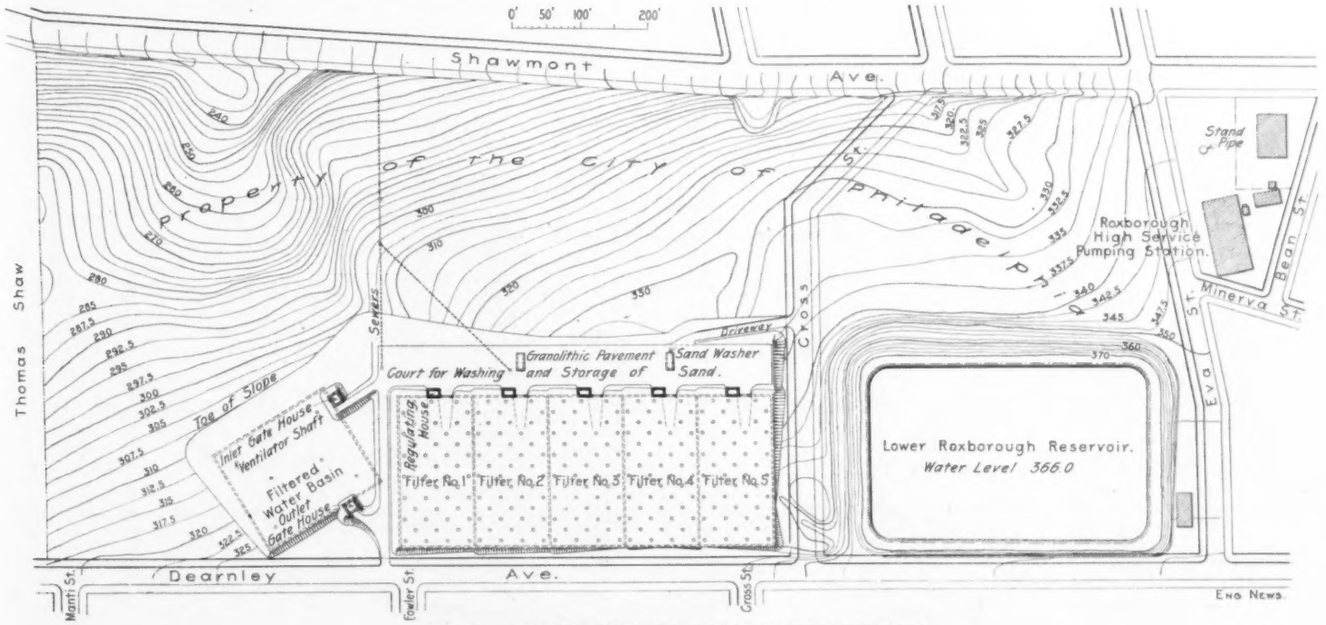



FIG. 4. PLAN OF LOWER ROXBOROUGH FILTER PLANT.

The raw water from the Delaware River will be delivered to preliminary filters by low lift pumps and thence flow by gravity through cast-iron pipes to the plain sand filters. The delivery pipes are as follows: Five 48-in. pipes along Delaware Ave. to Court No. 1, where two branch off and extend up the court, one on each side; four pipes to court No. 2, where two more branch off, and two pipes to court No. 3, up which they turn. Branches 24 ins. in diameter from the court pipes deliver the water to the filter beds. There are also effluent and drain pipes as at the Belmont works. In a measure the Torresdale tunnel conduit is a portion of the filter plant, but it is of such size and importance that it constitutes an engineering work by itself, and is accordingly described in a separate article to follow.

LARDNER'S POINT PUMPING STATION.

The Lardner's Point pumping station consists of the present Frankford pumping station, known as engine and boiler house No. 1, of engine and boiler house No. 2, now under construction, and of engine and boiler house No. 3, being constructed just north of No. 2. Fig. 6 shows in plan boiler

and engine houses Nos. 1 and 2. Each of the two new engine houses, that is, Nos. 2 and 3, will contain six 20,000,000-gallon pumping engines, and each of the new boiler houses will contain six batteries of internally-fired marine boilers of 800 HP. each. The engines are of the vertical crank and flywheel triple expansion type, and are to have a duty of 130,000,000-foot pounds per 100 lbs. of coal actually burned in the boilers.

The system of conduits for the distribution of water to the pumping station embraces two main conduits leading from shaft No. 11 of the Torresdale conduit. The larger of these conduits, partly of a circular riveted steel pipe, 14 ft. in diameter and 28 ft. long, joined to the flange of a cast-iron nozzle, attached to the steel shell of the shaft, and at the opposite end to a horseshoe concrete-steel conduit equal in area of waterway to a 14-ft. circular pipe. The smaller conduit is a steel pipe 7 ft. in diameter and 28 ft. long, similarly connected to the shaft shell and an equivalent concrete-steel horseshoe conduit. This small conduit supplies engine and boiler house No. 1. The pump well of engine house No. 2 and the smaller conduit from shaft No. 11 connect into a concrete-steel horseshoe conduit equal in area to a 9-ft. circle, which extends eastward to the Delaware River. There are twenty-six sluice gates 23 ft. 4 ins. wide and 6 ft. high, operated with worm gearing for controlling the flow of water. These connections enable water to be pumped directly from the river until the filtered water is ready for delivery, when the river conduit becomes a dry chamber leakage from which is taken to a separate pump well and delivered to the sewers.

### OAK LANE RESERVOIR.

The purpose of the Oak Lane Reservoir is to compensate for the varying hourly rates of water consumption and to fix the head against which the Lardner's Point pumps will work. It is a constituent part of the Torresdale plant. It is a lined earth embankment reservoir, divided into two sections, each 375 × 515 ft. on the bottom, and 20 ft. 6 ins. deep, with a capacity of 70,000,000 gallons in the aggregate.

### ENGINEERS AND CONTRACTORS.

In the preceding general description of the Philadelphia filtration system no attention has been paid to the structural details or to the methods of construction. These will be considered in succeeding articles, the next of which will describe and illustrate the Torresdale Tunnel Conduit.

The engineering staff on the works described in this article was as follows:

| | First Assistant Engineers in charge of construction. | Contractors. |
|---|---|---|
| Lower Roxborough Filters. | Frank R. Fisher. | Daniel J. McNichol, Philadelphia. |
| Upper Roxborough Filters. | Stephen Harris, Frank R. Fisher. | Daniel J. McNichol, Philadelphia. |
| Belmont Filters. | LaMonte Lloyd, Charles H. Paul. | Ryan & Kelley, Philadelphia. |
| Torresdale Filters. | Fred. C. Dunlap, (Mem. A.S.C.E.) | Daniel J. McNichol, Philadelphia. |
| Lardner's Point Pumping Station, No. 2. | S. M. Swaab, (Assoc. Mem. A.S.C.E.) | George C. Dietrich, Philadelphia. |
| Oak Lane Reservoir, | D. Jones Lucas, (Mem. A.S.C.E.) | R. A. Malone & Co., Philadelphia |

All the works forming the improvement, extension and filtration of the water supply are conducted by the Department of Public Works, of which Mr. William C. Haddock was director from the inception of the work to April, 1903, since which date Mr. Peter E. Costello has been director.

## NOTES ON THE SOFTENING OF IOWA WELL WATERS.

By Nicholas Knight,* A. M., Ph. D.

The following is a condensed record of some investigations into the softening of hard waters recently carried out in the chemical laboratory of Cornell College by Mr. C. G. Eldredge. The water which it was endeavored to treat is that used for the supply of Mt. Vernon, in Eastern Iowa, and is probably a fair type of the various supplies in the dolomite region of the Mississippi Valley. The water is pumped from a well 330 ft. in depth, of which 315 ft. is in the Niagara magnesian limestone. The substances, therefore, which cause the hardness are calcium and magnesium carbonates, with a small amount of calcium sulphate.

(1) The total amount of the solids in the water was obtained by evaporating 500 c.c. to dryness in a weighed platinum dish of 150 c.c. capacity, and afterwards drying in an air bath at 110° to constant weight. From this the silica, iron and alumina, calcium and magnesium were determined. The amounts of sulphates and alkaline chlorides were estimated from other portions of water. On account of a possible variation in the quantity of dissolved substances in such waters, the entire amount required for these experiments was taken at the same time, and kept in a cool place in glass-stoppered bottles. The numbers given express the amounts of the various substances in 100,000 parts of the water:

| | |
|---|---|
| Total solids in platinum dish | 28.86 |
| $Ca\,CO_3$ | 12.47 |
| $Mg\,CO_3$ | 10.42 |
| $Ca\,SO_4$ | 0.980 |
| $Si\,O_2$ | 2.12 |
| $Fe_2\,O_3$ and $Al_2\,O_3$ | 0.266 |
| Na Cl and KCl | 2.34 |
| | 28.60 |

*Professor of Chemistry, Cornell College, Mt. Vernon, Iowa.

### THE EFFECT OF BOILING ON PRECIPITATING THE CALCIUM AND MAGNESIUM CARBONATES.

(2) 500 c.c. of the water was placed in a liter flask of Jena glass, heated to boiling with a triple burner, and boiled vigorously for two minutes; 10 c.c. of the water evaporated by the boiling. The flask was allowed to cool, and the contents were filtered, and the filtrate evaporated to dryness in the platinum dish and treated in every respect like the unboiled specimen.

The amounts obtained were as follows:

| | |
|---|---|
| Total solids in the platinum dish | 23.38 |
| $Ca\,CO_3$ | 9.27 |
| $Mg\,CO_3$ | 9.53 |
| $Ca\,SO_4$ | 0.98 |
| $Si\,O_2$ | 1.68 |
| $Fe_2\,O_3$ and $Al_2\,O_3$ | 0.25 |
| Na Cl and KCl | 2.34 |
| | 24.05 |

The difference between the results here obtained and in (1) is due chiefly to the precipitation of calcium carbonate. The magnesium suffered a comparatively slight change. The boiling water in this and subsequent experiments did not seem to dissolve the glass as shown by the amount of silica obtained.

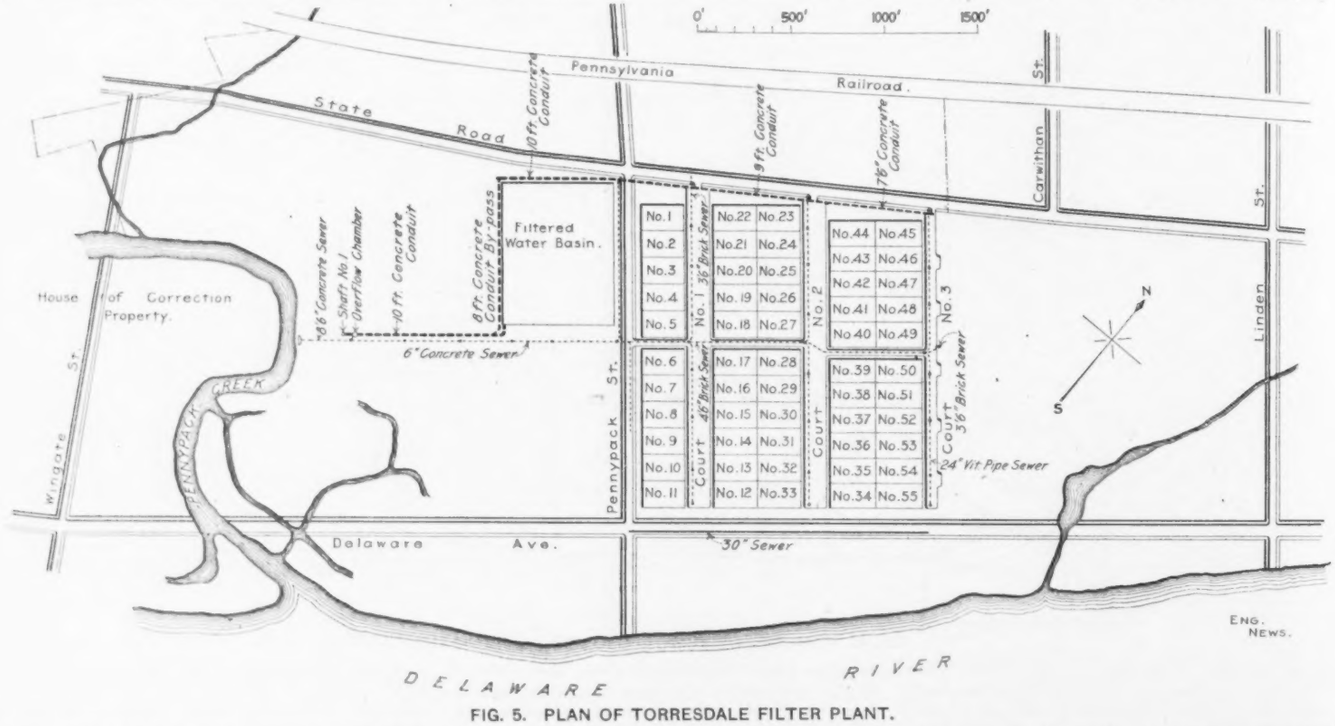



FIG. 5. PLAN OF TORRESDALE FILTER PLANT.

(3) 500 c.c. of the water was heated to boiling in the flask and the boiling was vigorously continued for ten minutes. 45 c.c. of the water evaporated during the time. The total solids obtained in the platinum dish, 20.00:

| | |
|---|---|
| $Ca\,CO_3$ | 4.92 |
| $Mg\,CO_3$ | 9.75 |
| $Ca\,SO_4$ | 0.98 |
| $Si\,O_2$ | 1.78 |
| $Fe_2\,O_3$ and $Al_2\,O_3$ | 0.32 |
| Na Cl and KCl | 2.34 |
| | 20.09 |

(4) 500 c.c. of the water was boiled for twenty minutes in the flask used in the previous experiments. 70 c.c. evaporated. The filtered residue evaporated to dryness gave as the total solids, 19.18:

| | |
|---|---|
| $Ca\,CO_3$ | 4.25 |
| $Mg\,CO_3$ | 8.52 |
| $Ca\,SO_4$ | 0.98 |
| $Si\,O_2$ | 1.96 |
| $Fe_2\,O_3$ and $Al_2\,O_3$ | 0.27 |
| Na Cl and KCl | 2.34 |
| | 18.32 |

Boiling twenty minutes thus removes about 66% of the calcium carbonate and 18% of the magnesium carbonate, or about 44% of the temporary hardness. It should also be noted that where the hardness is more largely due to calcium and magnesium sulphates, with smaller amounts of the carbonates, boiling to remove the carbonates would tend to increase the concentration of the solution of sulphates, and therefore the hardness of the water instead of diminishing might be increased.

THE EFFECT OF LIME WATER ON THE CALCIUM AND MAGNESIUM CARBONATES.

300 c.c. of the water was shaken in a flask with 150 c.c. of lime water. The mixture was allowed to stand 24 hours when it was filtered and evaporated to dryness. The total solids were found to be 15.10.

All of the magnesium carbonate was removed, but an excess of calcium oxide from the lime water remained. The experiment was repeated a number of times to find the minimum of lime water that would leave the smallest quantity of total solids. The lime water was prepared from distilled water. The following proportions were used:

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| 112½ | c.c. | lime | water | to | 300 | c.c. | of | the | water |
| 75 | c.c. | " | " | " | " | " | " | " | " |
| 100 | c.c. | " | " | " | " | " | " | " | " |
| 37½ | c.c. | " | " | " | " | " | " | " | " |
| 90 | c.c. | " | " | " | " | " | " | " | " |
| 30 | c.c. | " | " | " | " | " | " | " | " |
| 22½ | c.c. | " | " | " | " | " | " | " | " |

In each case the total solids obtained were comparatively large, either from the excess of lime water used, or because the amount of lime water was insufficient to remove the carbonates to any extent. The experiments were repeated with baryta water, but the results were also unsatisfactory. In a number of trials it was sought to remove the excess of lime by acidifying with a stream of $CO_2$. On evaporation the $CO_2$ would pass off and the solution would again react alkaline. In other cases the mixture of the water and lime water was allowed to stand in a shallow dish exposed to the air for a number of days, and then filtered and evaporated. No attempt was made to remove the excess of calcium oxide with sodium carbonate.

A more satisfactory result was obtained by taking 300 c.c. of the water and using two or three drops of a tenth normal solution of silver nitrate as an indicator. The lime water was dropped from a burette until the mixture showed an alkaline reaction. 50 c.c. of lime water was required. Total solids, 15.14.

| | |
|---|---|
| $Ca\ CO_3$ | 5.21 |
| $Mg\ CO_3$ | 4.23 |
| $Si\ O_2$ | 2.12 |
| $Ca\ SO_4$ | 0.98 |
| $Fe_2\ O_3$ and $Al_2\ O_3$ | 0.26 |
| Na Cl and KCl | 2.34 |
| | 15.14 |

The experiment was repeated, using as an indicator two or three drops of phenolphthalein solution, made by dissolving 1 gram of the powder in 200 c.c. 95% alcohol. 50 c.c. lime water was again required. The result is as follows:

| | |
|---|---|
| $Ca\ CO_3$ | 2.41 |
| $Mg\ CO_3$ | 4.13 |
| $Ca\ SO_4$ | 0.98 |
| $Si\ O_2$ | 2.12 |
| $Fe_2\ O_3$ and $Al_2\ O_3$ | 0.26 |
| Na Cl and KCL | 2.34 |
| | 12.24 |

The best results seem to come from adding the lime water to the water, in the ratio of 1 to 6. The lime water can be tasted in the mixture, which is quite unfit for drinking purposes. This, of course, would not be an objection for boiler use.

## NEW TERMINAL WORKS AND ELECTRIC TRACTION OF THE PARIS & ORLEANS RY. AT PARIS, FRANCE.

The difficult and costly works for the improvement of the passenger terminal of the Paris & Orleans Ry., at Paris, France, have been completed, and the new tracks and facilities were put in service on July 1. In 1898 and 1899 an extension was built from the old terminal station to a new station on the Quai d'Orsay, near the Tuileries, and more convenient to the central portion of the city. This led to a rapid development of the suburban traffic, which caused trouble by interfering with the main line trains. The company had only a double track line into the city, and the frequent suburban trains making numerous stops, blocked the fast or through trains. It became evident that additional track must be provided, and it was decided to double the line for about 23 miles, to Bretigny, with a view to a future extension of 15½ miles to Etampes. The works were commenced in May, 1902, and completed by July, 1904, without any serious accident or serious disturbance to the traffic.

The two middle tracks are for the through fast trains, and for freight trains when the tracks are clear. The two side tracks are for the local trains. The space between the two middle tracks is 10 ft. 8 ins. wide; and the spaces between the middle and side tracks are 6 ft. 9 ins. wide. The unusual width of central spacing is to ensure safety to the men at work on the track and to allow room for placing the signals. All grade crossings for trains in opposite directions have been eliminated, but connections between the two groups of trench have been provided at various points for use in case of emergency, under special precautions. Their use in regular service is forbidden. All road crossings have been eliminated, which has involved heavy expenses and the modification of grades of both the roads and the railway. Subways are provided at all stations. Reinforced concrete has been largely employed on the various works, owing to its durability and the great rapidity with which the works could be constructed with this material. The lines are worked on the block system, with Lartigue semaphores, as on the other parts of the railway.

Two tracks in tunnel extend from the Quai d'Orsay terminal station to the next or Austerlitz station, and there divide into four tracks. All trains, inbound and outbound, stop at this latter station, which also has freight sheds for fast and slow freight service. The slow-freight shed is conveniently located for outbound trains, but as it is on the opposite side from the inbound tracks, the inbound freight trains reach this part of the station by a special track which leaves the local track 1¼ miles distant and passes under the group of main tracks (which are raised at this point), thus avoiding a crossing of these tracks at grade.

At 12½ miles from Paris is the important junction station of Juvisy, where special works have had to be built. There are 12 main tracks with platforms for passengers, and a branch line of the Paris, Lyons & Mediterranean Ry. enters the station on the left. The freight and passenger station is in the angle between the two lines and beyond these, on the right, there is an important freight yard where the trains are made up. It was necessary to provide three connections with this yard, one for the line to Paris, one for the local freight station, and the third for the line to Orleans. The three connections are made without grade crossings by three overhead steel bridges of great skew, at the head, middle and rear of the station. At the end of the four track line, at Bretigny, the Vendome branch leaves the main

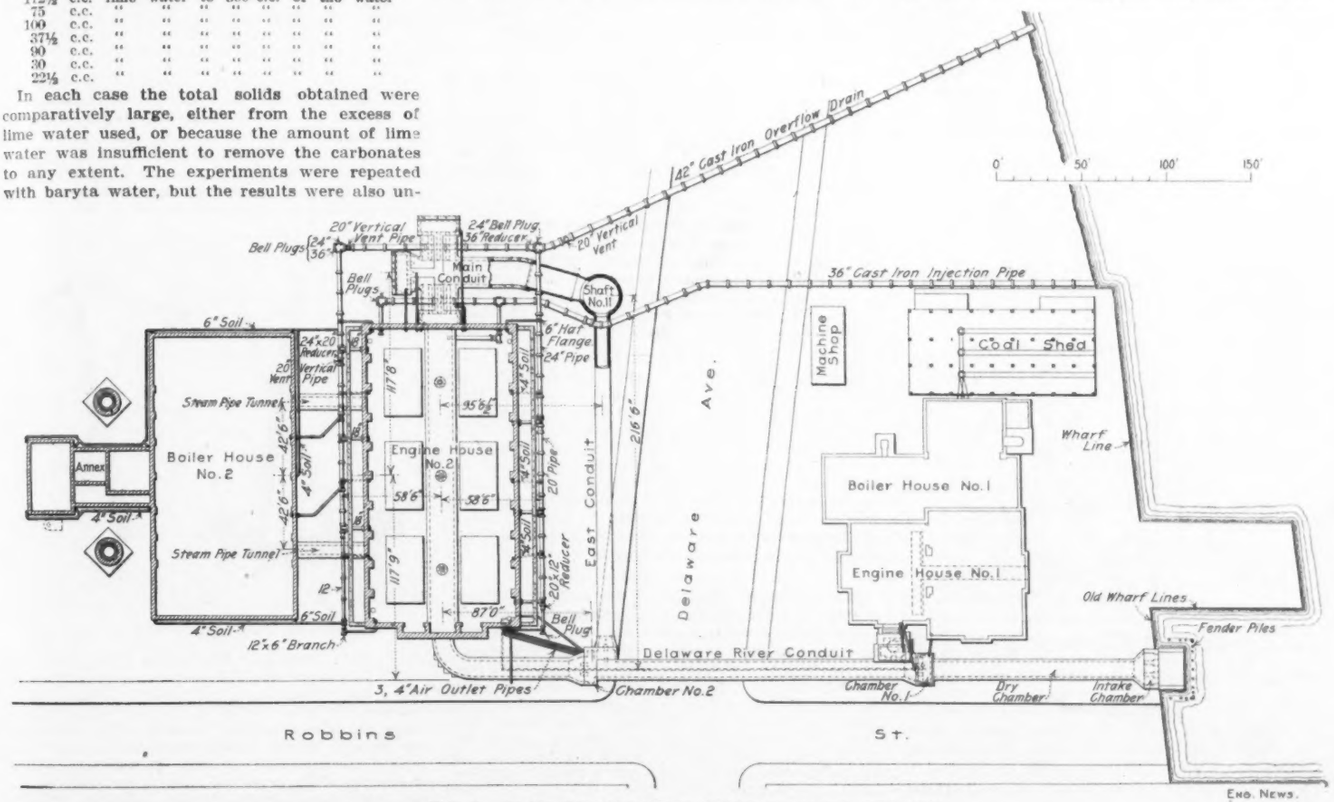



FIG. 6. PLAN OF LARDNER'S POINT PUMPING STATION.

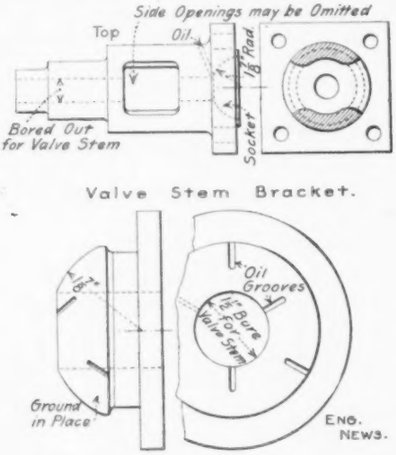
line by a deviation in order to avoid a grade crossing of the main tracks.

The double track underground section between the Austerlitz station and the Quai d'Orsay terminal is operated by electricity on the third-rail system, with electric locomotives which are attached directly to the regular trains. Electric traction for the local or suburban trains has been extended to Juvisy, 14¼ miles, an additional generator being installed in the power house and two sub-stations being established at Ivry and Ablon. Three-phase alternating current of 5,500 volts is employed, being transformed to continuous current of 550 volts for the conductor rail. In addition to this electric traction, electric motor cars will be employed for certain local trains which run only as far as Juvisy.

The total cost of all these improvements, including the electric traction plant and equipment, was about $6,000,000.

## BALL JOINT FOR PACKING CORLISS VALVE STEMS.

The valve stems of Corliss engines, which have a rotary motion, usually have packing held in place with glands secured by studs or screws and nuts. This necessitates making the valve bracket long enough to enable the glands to be assembled and removed, holes being formed in the bracket to make the parts accessible. An improved design which does away with this multiplicity of parts consists of forming a hemispherical socket or seat in the bracket (around the opening for the valve stem) and fitting the valve stem with a "ball




Ball Stuffer for Valve Stem. (Enlarged)

Ball Joint for Packing Valve Stem of Corliss Engine.

stuffer" ground to fit the seat and held against the bracket by a collar. The steam pressure holds the "stuffer" tight against the seat. This not only enables the number of small parts to be greatly reduced, but also reduces the cost of maintaining and repairing the gland packing, while it also allows the bracket to be made shorter and without openings.

This device, which is also applicable to the steam drums of paper mills, is the invention of Mr. Leonard Single, of Hamilton, O. It has been applied to a Hamilton-Corliss engine (Hooven, Owens & Rentschler Co.) with cylinder 18 × 36 ins., and is said to be proving very satisfactory.

## A CONVENIENT TOOL FOR FINDING PIN-HOLE CENTERS ON TRUSS MEMBERS.

Every engineer or draftsman is familiar with the common method of finding the center of a circle by drawing two chords and erecting perpendiculars from their centers. We illustrate herewith an instrument for solving the same problem mechanically. It was devised for use by a bridge inspector for quickly finding the pin-hole centers of bridge truss members. The photograph was sent us by Mr. G. B. Ashcroft, Assoc. M. Can. Soc. C. E., of the Delano-Osborn Engineering Co., who writes us as follows concerning it:

Sir: The accompanying photograph shows two instruments used by us in determining the centers of bored pin-holes in the truss members of pin-connected bridges. The material used in their construction is thin sheet steel, same as is employed in making saw blades. Arm Y rotates about the pin B which is rigidly attached to the arm X. Pins A and C are also rigid. Arm X is made of two sheets, arm Y being a single plate, sliding between them.

The edges (left hand, as shown) are made to coincide with the perpendicular bisectors of the lines which join the centers of the pins B-C and B-A. When these three pins are brought to bear against the circumference of any pinhole, the edges of the arms become perpendiculars to the two chords of the circle, and their intersection becomes the center of that circle.

The instruments shown above were devised for use during the shop inspection of the Fraser River bridge, a structure recently erected at New Westminster, B. C. by the Dominion Bridge Co., of Montreal. The several large pin-connected spans of this bridge, made it desirable that our shop inspector should have a rapid and accurate means of finding the centers of the bored holes in the truss members. The tools as made for this work, have a distance of 2 ins. between pin centers, and a length of 6½ ins. in the arms, which gives them a range over holes from 3 to 11½ ins. in diameter.

If skilfully made, they are accurate within practical limits, and we can recommend them as time savers to any one with much of this class of work to handle.

Yours very truly, G. B. Ashcroft.

Manning Chambers, Toronto, Can., May 29, 1904.

BIDS FOR A SALT WATER FIRE PROTECTION, to be located at Coney Island, Borough of Brooklyn, New York City, are wanted until Aug. 31. The work includes gas engines and triplex pumps, an engine house and high pressure mains. Mr. John T. Oakley, Park Row Building, New York City, is Commissioner of Water Supply, Gas and Electricity.

THE POLLUTION OF THE NEPONSET RIVER by manufacturing wastes is to be ordered stopped by the Massachusetts State Board of Health. At least it is reported that Attorney-General Parker has been requested to bring action to that end. Many and various industrial plants at Norwood, Hyde Park, Canton and elsewhere would be effected by the action.

TYPHOID FEVER AMONG LABORERS on the Jerome Park Reservoir gave rise to sensational stories about danger in the water supply of New York City. The cases have been attributed by the city department of health to the drinking by the laborers of polluted water which, we assume, will be diverted from the reservoir before it is put in use. The present water supply is not involved and the future supply need not be if obvious sanitary precautions are taken to keep the reservoir site free from pollution by the workmen and to exclude the inflow of polluted reservoir to the completed reservoir.

THE GARBAGE CREMATORY AT SAN FRANCISCO is giving rise to complaints of a smoke nuisance and it is stated that spraying apparatus has been placed in the flues to try its effect on reducing the smoke. The crematory is owned by a company which holds a franchise under which it claims that all private scavengers must bring the garbage collected by them to the crematory and pay for having it burned. The scavengers have resisted this claim for several years and the matter is now in the U. S. Courts. The crematory, which is a large one, on British lines, was described at length in Engineering News of May 17, 1900.

INVESTIGATIONS ON THE SETTING OF HYDRAULIC cements is the subject of a prize competition recently announced by the Prussian Minister of Public Works in conjunction with the Society of German Portland Cement Manufacturers. A sum of 15,000 M ($3,600) is available for prizes. The investigations are to deal with the chemical actions concerned in the setting of hydraulic cements, and the monograph upon them must be written in the German language. There is no restriction as to nationality. The monographs must be delivered by 3 p. m., Dec. 31, 1906, at the Ministry of Public Works, 80 Wilhelm St., Berlin, W., Germany. A copy of the conditions of the competition and all related facts may be had (in German, French or English) on application to the ministry referred to.

CHANGES IN THE WATER SUPPLY to the University of Arizona, at Tucson, Ariz., are described in a note that we have received from Mr. G. E. P. Smith, Professor of Physics and Engineering at that institution. Professor Smith's note, with some general comments bearing upon the low efficiency of many pumping plants in the West, is as follows:

The thousands of pumping plants throughout the West used for irrigation are an inviting field for investigation, for many of them have a very low efficiency and there is great room for improvement.

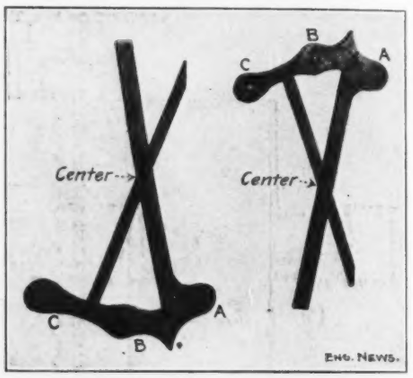
The University of Arizona has its own water supply from a dug well 108 ft. deep. The water is used for domestic purposes in twelve buildings and for irrigating a large campus. Last March a 6-in. hole was driven to the bottom of the well to a depth of 44 ft. and cased with steel pipe perforated with 3-16-in. holes. The capacity of the well was raised thereby from 8,100 gallons per hour to over 16,000 gallons, at a total cost of less than $50. Since then a two-stage centrifugal pump, direct-connected to a 15-HP. motor, has been installed to replace the steam pump formerly used. Careful tests made before and after the change demonstrate a saving of over 25% of the former cost, and an annual saving of $350, enough to pay for the new installation every two years. It is fair to assume that a similar waste might be stopped in hundreds of small pumping and other power plants.

CHICAGO'S LOW MORTALITY FOR JULY, which was the lowest in total deaths for the past eleven years, is attributed in part to the improved character of the water supply. According to the bulletin of the Chicago Health Department for the week ending Aug. 6:

Among the important causes contributing to the phenomenally low death rate of July—after the propitious weather—is a remarkably good sanitary quality of the public water supply. There has been no such record of "safe" since daily examinations were begun in 1895 as during the last two months, and for the first time during the nine years a rainfall of more than 0.75-in. in 24 hours has failed to cause water pollution. On the 31st nearly an inch (0.91) fell, but it had no effect on the chemical determinations, while, on the other hand, the bacterial examinations showed a marked reduction of the bacterial content. The value of the continuous flow from the lake through the drainage channel is not yet appreciated. When the remaining lake-emptying sewers are diverted into the channel Chicago will have continuously the purest, as it already has the most abundant, water supply of any large city.

Credit is also given to the improved character of the milk supply, following the extensive dairy inspections of the past few months. The mortality rate for July, 1904, was 11.95 per 1,000.

A NEW OUTLET SEWER FOR LOS ANGELES, CAL., has been put under construction. It will utilize a portion of the old sewer put in operation in March, 1894, and described and illustrated in Engineering News of Feb. 28, 1895. This sewer was 12.4 miles in length, extending from a point within the city limits to the Pacific Ocean. It was partly of brick, 52 ins. in diameter within the city limits, and was to comprise two 40-in. brick sewers outside the city, but the second conduit has not been built. Some of the sewer was in tunnel. At certain depressions in the line of the sewer the brick conduit gave way to two long inverted siphons of wood stave pipe. The last 1,200 ft. of the outlet consisted of 24-in. cast-iron pipe, part of which extended into the ocean, to a final depth of 20 ft. In our issue of Feb. 28, 1895, we published a brief article on the operation of the old outfall, and in our issue for Nov. 8, 1900, a long article appeared, describing the disintegration of the mortar of the brickwork and the rusting of the ironwork, both supposed to be caused by gases from the sewage. The new outfall sewer will be 11.77 miles in length and will utilize a portion or portions of the old one. It will be of brick, from 44 ins. circular to 73 × 60 ins. elliptical in size and about two miles of it will be in tunnel. Some 3,000 ft. of the old outfall will be torn out and another section of it will have its joints repainted and the whole inner surface plastered with cement. The city has let three contracts for the work, aggregating some $800,000; one for cement, one for brick, and one for construction. The brick are being made on or near the line of the sewer. It would appear from the information at hand that the new outfall is designed, in part, as a substitute for the second 40-in. conduit proposed when the first outfall was built and that the change in plan has been brought about by the deterioriation of the brickwork and ironwork composing the old outlet. Mr. Harry F. Stafford is city engineer of Los Angeles, and Stansbury & Powell are contractors for construction of the sewer.




A Tool for Finding Pin-Hole Centers.

# ENGINEERING NEWS

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The practical success of copper sulphate as an algaecide seems assured. Among the places where the method has been used with apparently unqualified success are Elmira and Cambridge, N. Y. (Engineering News, July 14 and 28, respectively), and Butte, Mont. An interesting article on the treatment at Butte has been written by Mr. Eugene Carroll, M. Am. Soc. C. E., and is published elsewhere in this issue. The Butte case is a significant one, inasmuch as the reservoir involved there was constructed some ten years ago at no little expense and has been practically useless in summer since. Not only that, but, being deprived of the use of this reservoir in summer, it was necessary to hasten the development of an additional supply, involving both a large capital outlay and pumping half of the supply of the city to a height of 840 ft.

In our issue of July 28 we published a letter from Mr. Geo. T. Moore, who brought the copper sulphate treatment before the public, stating that the method had been successfully used "in reservoirs of at least several towns in ten different states, and the results have been as satisfactory when treating 600,000,000 gallons as in reservoirs of smaller capacity." It is expected by Mr. Moore that a second bulletin, reviewing the practical work done with copper sulphate from the start, will be published this Fall. Such a bulletin would be received with great interest. It is to be hoped that it will include some results on the prevention of algae growths in filtered and in ground waters, which have been stored in uncovered reservoirs.

If the experience, described elsewhere in this issue, in obtaining cinders for a sewage filter bed can be considered as typical, then it is no wonder that comparatively few such beds have yet been built in this country. Apparently neither the city for which the bed was built, nor the successful bidder, took much trouble to ascertain in advance whether or not suitable cinders could be obtained in the vicinity at a reasonable price. As a result, the contractor must have either put in a high bid or lost money on this part of contract, and the city, even though the extra expense may have fallen on the contractor, has apparently got a filter bed composed of material that will soon break down. We are without knowledge of the name of the city or of the engineer for the sewage disposal works, and therefore take this occasion to say that the experience described seems to be an illustration of the tendency for some of our American cities and engineers to copy blindly British practice in sewage disposal without taking into account differences in local conditions. Of course it may be that suitable filter-bed material of any sort could not be readily obtained by the city in question, but we venture the assertion that most American cities can find something within their means more suitable for a sewage filter bed than the soft and decomposable stuff described in Mr. McCullough's article. It will be noticed that about two weeks after screening the fine stuff from one lot of the cinders the material had already so broken down that on re-screening a third of it was found to be fine dust. Even the larger and harder cinders, which were ground to reduce them to the specified size, "will break down enough in a short time to give dust sufficient to fill the voids" in the filtering material. If this be true, it would appear to be only a few months, at most, before the filter bed will be practically useless. We think it probable that better cinders could be obtained, and with less difficulty, in some parts of the United States, but in the light of our present knowledge cinders should be adopted anywhere only after a careful investigation of the character and quantity of the material available in the locality, and its first cost and durability as compared with other material.

The brief paper from an Iowa college chemical laboratory, published elsewhere in this issue, indicates some of the difficulties met with in softening hard well waters of complex composition; and the wisdom of experiment with the water used in a power plant before adopting any method of treatment and, indeed, before designing the plant. For example, open feed-water heaters are largely advocated and used as a means of removing scale from water before delivering it to a boiler. The experiments above referred to, however, show that with the particular water tested, heating to 212°, even when long continued, had comparatively little effect in precipitating scale. Possibly heating under boiler pressure to a high temperature might have been more effectual, but that plan does not appear to have been tried, and it is, therefore, impossible to say whether a closed-feed water-heater would have worked better than an open one. Unless an engineer can find available records of experience with a particular water, therefore, it will be worth his while to have a test of its behavior made before deciding on the type of feed-water heaters to be used for a power station.

It may be asked, what should be done where it is desired to use for power purposes a scale-carrying water which cannot be purified to a reasonable degree either by feed-water heaters or by chemical treatment. We see no better course under such circumstances than to install a cooling tower and use the same water over and over again. This will not only afford a purer water for the boilers, but will effect a saving in the water consumption which, on a fair-sized plant, may amount to a very considerable sum.

The paper in this issue by Mr. D. H. Maury on wells of moderate depth in water-bearing sand or gravel is notable, among other things, for the proper emphasis which it places on the corrosion of well points as a most important factor to be considered in fixing upon the design of a well. It is curious how generally inventors, and engineers too, it must be confessed, overlook the inevitable effect of wear and rust upon their devices, even when as in the case of a well the rapid and continuous action of rust is certain, and ought to be foreseen and taken into consideration. Such decay is objectionable enough in a machine or any other open-air construction, but it is many times more troublesome in permanently buried structures, as wells, for example. The buried structure is inaccessible for repairs, and for what is in many cases perhaps more important than repairs: inspection, to give warning of bad working condition or of the approaching end of the structure's life.

Of course, the engineer in designing a structure often makes a calculation of the comparative cost of (1) originally providing better protection against deterioration, and (2) renewing the structure at shorter intervals. But do such calculations always take account of all the factors affected? We believe not. For example, in the case of a well, or system of wells, supplying the water system of a community, it is easy to compute the cost of building and connecting up a new well when the old one fails; but it is hardly possible to state in figures the loss to the public from insufficient water supply caused by the gradual failure of the wells. It seems much safer to adopt the general principle that, in all cases of buried structures intended for permanent service, the original design should be based on maximum permanence.

Closely connected with the field of water supply, as well as with many other fields of constructive or operative engineering, is the subject of pumps. At present a development of great moment, though not very obtrusive, affects this subject—the evolution of the reversed-turbine type of pump as a successor to the long-established centrifugal pump. Rotary pumps capable of working against great pressures with a high degree of efficiency are becoming available. The paper of Mr. Maury, above referred to, touches on this theme suggestively, though briefly. It points out the principal advantages which the new type of pump may offer: as against centrifugal pumps, its efficiency and its ability to work against high heads; as against plunger pumps, its compactness, its ideal adaptability to driving by direct-connected electric motor as well as any other source of power, and its simplicity in operation and maintenance. The possibilities open before the turbine pump are very large; it promises to capture a considerable part of the field now occupied by reciprocating pumps. The realization of this promise, however, is still some distance in the future. Our theoretical knowledge of the turbine-pump and our practical ability to adapt it to various service conditions are yet but nascent. It is quite safe to assume that the pumps of this class that are on the market to-day are merely pioneers, and that further study and experience will evolve many radical changes in general design and details.

The turbine-pump appears to have some limitations that may have an important bearing on its manner of application. When running at constant speed and against a fixed head, the turbine-pump has a constant discharge. In order to vary the discharge, it is necessary to vary not only the speed, but also the "gate-opening," otherwise the efficiency drops off rather sharply. Whether it would prove necessary to fit such pumps with movable guide-blades as are used in some turbines remains to be learned. Again, if the pump is to work under varying head, as in drainage work, it would probably be required to run at constant load, the full load of the driving motor. It would then have to be driven at varying speed. To accomplish this without lowering the efficiency of the pump special devices may be required, possibly an electric motor of special winding and control.

Inherently the turbine pump, like the hydraulic turbine, is a constant-speed, constant-discharge machine, and its adaptation to variable conditions will doubtless require much study and practical trial. Whether or not it will find extended use for general water-works service (an important case of variable service) will depend largely on the success of this work of development. But even to-day there are very many situations where the turbine-pump is the ideal machine. That it is as useful for low as for high pressures is excellently illustrated by the "propeller" pump of the Milwaukee flushing tunnel, built nearly fifteen years ago. That pump, working against a head of only 3 to 5 ft., is a true reversed turbine of the axial flow variety.

It often happens that after an engineer has drawn up a specification and form of contract, the papers are turned over to a city or corporation counsel who usually considers it his province to convert what may have been a fair contract into as one-sided a contract as is possible for human ingenuity to construct. From a contract that has

apparently met with this treatment, the following clause has been selected:

It is also mutually understood and agreed that if the contractor shall assign or transfer either absolutely or conditionally by order or otherwise, the compensation or any part thereof to which he may become entitled under the contract before such compensation is actually earned, the city may, for that reason, cancel the contract and retain all compensation at the time of such assignment or transfer due or owing on the contract; or the city may, at its option, recognize any such assignment and transfer as valid. The option of the city in that regard shall be exercised by the Commissioner of Public Works, and the recognition of any assignment or transfer as valid shall not preclude the city from cancelling the contract for or on account of any other or subsequent assignment or transfer. The contractor agrees not to so assign or transfer his compensation, or any part thereof.

And it is also mutually understood and agreed that the city may, at its option, declare the contractor in default and cancel this contract, in case proceedings in bankruptcy are instituted by or against the contractor (or either of them, if there is more than one), or in case proceedings supplementary to execution are instituted against the contractor (or either of them, if there is more than one); and if the city shall so cancel the contract, it may complete the work or improvement as herein elsewhere provided. Such option shall be exercised by the Commissioner of Public Works.

Here we have a clause virtually prohibiting a contractor from borrowing money with which to buy materials or pay for labor, using the contract work to be done as his security. It may be, and often is, argued that some such clause is needed to protect workmen and material men. What, then, is the function of the bondsmen? Are not bonds given to provide for a contractor's possible failure? No lawyer, and certainly no engineer who has been identified with a contracting firm, will claim that such a clause as the above is not an unreasonable burden upon the party of the second part. There is a material difference between assigning a contract in its entirety, and between assigning a part of the compensation for work to be done. Were such a clause as this universally enforced, a large number of reliable contracting firms would be compelled to handle much less work annually.

As for that part of the clause permitting the city to cancel a contract if a member of a contracting firm is the defendant in bankruptcy proceedings, we need but to say that it is wholly uncalled for. It might readily be used as a weapon of persecution, but the main point to be urged against it is that it is uncalled for where reliable bondsmen have guaranteed the performance of the work. A more careful attention to the responsibility of bondsmen would lead to far better results than can ever come from loading down a contractor with restrictions and conditions such as those above given.

Every unnecessary or unfair clause in a specification has its part in limiting competition, and in lowering the standard of honesty among contractors. A clause that may be used as a club can be avoided in one of two ways, either by not bidding on work governed by the clause, or by using "graft" to insure that it shall be a dead letter.

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A somewhat careful study of practice in the matter of security required to be submitted with bids, shows that there is a great diversity of opinion among those who draw specifications. One engineer requires a certified check of $1,000; another engineer prefers a certified check, or draft, of 5% of the total bid; another wants 10%; still another expresses satisfaction with a "bid bond" of a surety company. Although it may be admitted that this is a matter of less importance than many other features governing the letting of contracts, still there are times when it becomes of decided importance to certain contracting firms. Certified checks are often held for weeks pending the award of a contract; and, if the contract is a large one, a correspondingly large sum of money is tied up. It would seem a sufficient security that the lowest bidder will accept the contract if he is required to deposit a certified check of a definite, but moderate amount; and an equally good, if not better practice would be to require a surety company's "bid bond" accompanying the bid. There are apparently many of the younger engineers who are not aware that surety companies will furnish such bonds.

One of the incidental objections to requiring a certified check of, say, 10% of the total bid, is that the contractor thus discloses the approximate amount of his bid to his banker. It often happens that the members of competing contracting firms are also stock owners in banks, and it has been rumored more than once that they have used their influence to advantage in learning the bids of certain competitors on public works contracts. Be that as it may, there is another and often very important reason why a certified check for a given percentage should not be required, namely, where contractors are expected to come from a distance to bid upon work, and will not have time to look the work over and send a check back to be certified. Under such conditions contractors are often put to a great deal of trouble in order to comply with conditions, and in many instances have been prevented from bidding at all.

In view of these facts, would it not be well if the common practice were to require either a "bid bond" or a certified check of a definite number of dollars to accompany each bid? The amount of such a check should be based upon the engineer's estimate of cost, and might well range from 5% on large contracts to 10% on small contracts. It is rare indeed that a contractor backs out of signing a contract, no matter how much his bid is below that of his nearest competitor, regardless of the actual size of his certified check.

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It is announced that the Building Department of the City of New York will materially increase the size and quality of its corps of inspectors, by aid of a special appropriation. This may be considered as indirectly an outcome of the disastrous Darlington Hotel collapse last March. The first result of that accident was that the Building Department was given increased power over construction work, specifically empowering it to stop work summarily on any work where its rules or the provisions of the Building Code are violated. Such power and an adequate inspecting corps are both of them essential to the proper conduct of a building department; either of them might have prevented the Darlington disaster. The evidence at the Coroner's inquest on that case showed a lamentably inadequate inspection, due mainly to the small number of inspectors available. Under such conditions the most complete building law fails of its purpose because it cannot be enforced.

The desirability of making building laws highly detailed and complete in their specifications is, perhaps, subject to argument. We have, some months past, given reasons against such a plan, in this column. But the need for thorough and efficient inspection, with sufficient policing power to back it up, can not be questioned. Experience in every city proves that those who build have rarely a desire other than to build as cheaply as possible. Baltimore, in its rebuilding of the territory devastated by the conflagration of last February, has abundant confirmatory evidence to offer.

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## THE USE OF FORMULAS IN THE DESIGN OF ENGINEERING WORKS.

What is scientific designing? In the minds of some engineers it appears to be the reduction of everything in the way of proportioning the parts of a structure or a machine to a mathematical process. In their minds an equation must be written, with the stress to be sustained on the one side and the unit resistance of the material on the other, in order to make the designing "scientific."

This is undoubtedly the process that should be pursued where the conditions admit of close calculation, as in bridge members for example, to take the most familiar illustration; but a large proportion of the work which the engineer has to do does not lend itself to mathematical analysis so readily. What method should the engineer adopt for the solution of such problems.

This question is raised by a correspondent in the following form:

Are the foundations of engines, say of a large air compressor, designed scientifically; or are the dimensions obtained by rule of thumb?

If the former, where can such information be found? I have looked up Hutton's works and many hand books; but while writing learnedly they all carefully avoid giving definite instructions.

What does our correspondent mean by "designed scientifically." If he means by it that all the stresses on the foundation are computed and the foundation is given such dimensions as to stress all parts of the foundation to their safe working limit, then engine foundations are not "designed scientifically." But if it be considered what would be involved in making a detail study of all the elements involved in the design of an engine foundation and assigning numerical values to every element so as to reduce the whole to a mathematical expression, it will probably be conceded that the best way to proportion engine foundations is by skill and good judgment on the part of the engineer in charge.

A reciprocating engine exerts a varying load on its foundation due to the unbalanced reciprocating and rotating weights. The purpose of the foundation is to absorb by the inertia of its mass the pulsations or vibrations of the engine. A foundation built on solid rock or hardpan may well be of very small mass, whereas a foundation resting on soft ground or on long piles may need to be very heavy to prevent the transmission of the vibration to adjoining structures. It is, we maintain, the most scientific engineering to use formulas only when and where they actually aid in securing a desired result. Probably it would be possible to work out an empirical formula for the size of engine foundations in which a coefficient should be used to represent the capacity of the material supporting the foundation to resist vibration. Perhaps it was some formula of this sort that our correspondent expected to find in the text books. But after the formula was made, it would require just as much judgment to set a value for the coefficient; and the engineer would frequently find that he was in reality deceiving himself by applying exact methods of mathematics to solve a problem which admits of no exact solution.

This is really the point which seems worth the consideration of engineers and engineering educators: In the endeavor to substitute "scientific design" for "rule of thumb," is there not danger of applying what we may term "the formula method of designing" in places where it is not a help but a hindrance?

But the reader may object, how should it be a hindrance? Scientific design consists, certainly, in the intelligent proportioning of materials to stresses, and the advantageous adaptation of means to ends. The engineer must have, to design successfully, a clear understanding of the forces at work, and of the capability of the materials at hand to resist them. He must form in his mind some equation between these two; then why should he not write down this equation in the shape of a formula?

This argument is a fair one and deserves a fair answer. There is doubtless no harm in that step of the process, since the engineer merely makes the computations on paper which he might make mentally. The harm comes when this formula is preserved for use on other problems and very likely by other engineers. By and by it gets into text-books and is used by men who hardly understand its significance, and who are likely, therefore, to stumble in attempting to apply it.

It is all very well for an engineer for himself to study out the stresses exerted on an engine foundation and write down his own rules for proportioning them; but when this is reduced to a cut and dried algebraic formula, and some engineer attempts to apply it to his own problem by the simple process of substituting the known values and estimating the unknown ones without appreciating just how great is their influence on the final result,—when this class of work is done and trouble results, the public wonders what is the matter with the engineering profession.

Engineering is often referred to as the profession which deals with matters of mathematical exactness and it is contrasted with other professions which have to do with fields of work where good judgment is the only reliance of the successful practitioner. But the actual fact is that sound judgment lies also at the base of sound engineering; and neither the physician or the lawyer will prove a greater failure without it than will the engineer.

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It happened after we had written the above answer to our first correspondent that a second letter was received, which forms an even better illustration of the subject under discussion. The

query of our second correspondent was as follows:

Will you kindly give a formula in your question column for the thickness of abutments of concrete for highway bridges?

Perhaps the above comments are a sufficient answer to this inquiry; but if any reader still thinks it ought to be possible to reduce the design of such an abutment to a cut and dried formula we suggest that he undertake to frame one for himself. He can, for example, let a represent the character of soil on which the abutment rests; b, the sort of material behind it; c, the climatic conditions, degree of frost, etc., to which the structure is subjected; d, the load imposed by the superstructure; e, the quality and weight of the concrete. These quantities and a few others to represent height, batter, etc., could probably be juggled into a form in which they would assume one side of an equation, while t, the thickness of the abutment at the top, represented the other. Such an equation, however, would be no real aid to the intelligent design of a bridge abutment, and it would be a dangerous tool for an incompetent engineer to attempt to use.

Long ago it was written that there is no royal road to learning, and the formula method of designing is no royal road to the easy design of engineering structures.

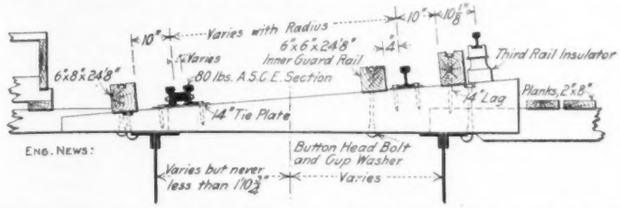



FIG. 1. TYPICAL TRACK-CONSTRUCTION ON CURVES, SOUTH SIDE ELEVATED R. R. CO., CHICAGO. SUPERELEVATION OBTAINED BY BEVEL TIE.

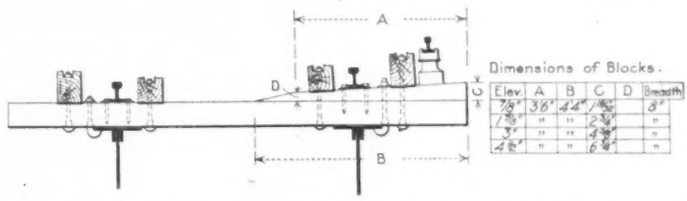


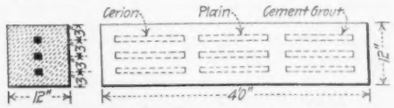

FIG. 2. SUPERELEVATION BLOCK USED WITH STANDARD 6-IN. TIE ON RECONSTRUCTION WORK, SOUTH SIDE ELEVATED R. R. CO., CHICAGO.

## LETTERS TO THE EDITOR.

### Experiments on Concrete as a Preservative of Steel Exposed to Sea Water.

Sir: In our concrete-steel work we have often had architects and engineers question the durability of concrete-steel construction when subjected to the action of salt water, a condition which we frequently meet in the construction of foundations for buildings and other structures in our seabound cities. Such records as can be found all tend to demonstrate that good dense concrete will protect steel indefinitely from corrosion whether in the presence of water or not.

As additional evidence on this subject, which is of vital importance in many cases, we made in October, 1903, four blocks of concrete each 12 ins. square by 4 ft. long, and placed in each of these blocks three series of ⅜-in. square twisted steel bars as indicated in the sketch herewith.




The rods were placed 3 ins. and 6 ins. from the surface. The first series of three rods was dipped in cement grout about six hours prior to concreting, giving the bars a good coating of cement. The second series was without any coating or paint whatever, corresponding to the usual practice in concrete-steel work. The third series was painted with Cerion paint, a petroleum product, about 20 minutes before concreting. Two of the blocks of concrete were mixed in the proportions of 1 part Lehigh cement, 2 parts clean sharp sand and 4 parts ¾-in. gravel. The other two blocks were mixed in the proportions of 1:3:5, using the same cement, sand and gravel.

The blocks were placed on the beach the day after they were molded, at Hempstead Harbor, Long Island, just above low-water mark. They were therefore submerged excepting for three or four hours each day. Two of the blocks were broken up on July 11, 1904, at the age of about nine months. The other two will be left for another year. All the rods were perfectly preserved. The Cerion paint was still sticky, much as when the rods were put in the concrete. The bond between these rods and the concrete was very slight. Of the other rods, those unpainted seemed to have the greatest adhesion to the concrete, but in all cases the bond was excellent. The concrete was well mixed and with plenty of water.

Yours very truly, Turner Construction Co.,
H. C. Turner, President.

New York City, July 25, 1904.

### The Use of Copper Sulphate as an Algaecide at Elmira, N. Y.

Sir: A communication by Mr. G. T. Moore, of the U. S. Department of Agriculture, appeared in your issue of July 28, criticising my use of copper sulphate as an algaecide at Elmira, N. Y.

His criticisms were: That he had not been consulted previous to the treatment of the reservoir; that it is necessary that the specific conditions of the water, "the organisms to be destroyed, etc., be taken into consideration"; that the cost of the treatment was excessive, and that the treatment was not proper, inasmuch as a few fish were killed.

Had Mr. Moore made inquiries about this case I do not think that he would have written as he did.

Having had charge of the Elmira water supply for the past six years as chemist and bacteriologist it should be conceded that the condition of the water was known by me, and that the treatment was based upon that knowledge with certain objects in view that need not be mentioned in this connection.

The area of the reservoir and the dense growth of the algae in some parts required strong treatment; the asterionella particularly offered great resistance to the copper sulphate.

When the capacity of the reservoir and the amount of the algae are taken into consideration the cost was not excessive in view of the immediate beneficial results.

The death of a few fish was regarded in a favorable light, inasmuch as the number in the reservoir is very large.

Having had previous experience in the use of copper sulphate for algae I did not feel the necessity of consulting Mr. Moore on this subject.

Yours respectfully, James M. Caird.

271 River St., Troy, N. Y., Aug. 5, 1904.

### A New Field of Endeavor for Engineers.

Sir: As the prospects of employment for engineers, especially assistant engineers, are not very flattering for the immediate future, I am not too selfish to outline a plan whereby many in each state can find pleasant, independent and profitable employment, as follows:

Outfit.—One wagon, with one or two horses, as the condition of the roads and topography of the section requires; camping outfit for four persons; transit, level, etc.; drafting table, instruments, blue print frame, stationery, etc.; photographer's outfit and sufficient apparatus to make practical analyses and tests of soils.

Party.—One engineer to make land surveys, etc.; second man, who is a draftsman, photographer and chemist; third man for head chainman and general utility man; fourth, a cook, who must look after the horses, buy camp supplies, take care of the property, etc.

Plan of Work.—Start out in any farming district, arrange with a property owner to survey his place; have him show you places on his land that do not produce well. Make a careful survey of his farm. Deliver to him six blue prints of an attractively made map; photograph his improvements, family, points of interest, etc. Deliver to him a written report on his soil, giving formula for fertilizer most suitable for his poorly-producing land. Suggest most suitable crops for the different fields, give advice about fruit trees, drainage, etc.; in short, a comprehensive exposition of his property, all of which can be quickly made. If necessary send the soil samples to the nearest university for analysis; send the photograph proofs to some regular photographer. It will be found that such an outfit will be overtaxed with work from the start.

Engineers must realize that the farmers, especially of the South and West, are now better off than ever before in the history of the country, excluding slave values before the war. Old surveys were carelessly made, farmers are now demanding a better class of talent. I find the plan a winner. There are many other details, involving advertising, etc. I will cheerfully furnish information to any engineers who would like to make a start on this plan.

H. W. Brennan.

Room 46, So. Ex. Bldg., Memphis, Tenn, Aug. 5, 1904.

### Superelevation in Deck Girder Bridges on Curves.

Sir: Replying to G. H. Holmes' inquiry in your issue of July 21, regarding the superelevation in deck girder bridges on curves, I beg to submit herewith two sketches, illustrating that which is common practice on elevated railroads in Chicago, and which I believe is the practice on steam railroads as well, particularly the method of using superelevation blocks. The girders are set plumb and level.

The life of tie timber (long-leaf pine) on elevated structure in this climate being from thirteen to fifteen years, the matter of renewals is a small item in maintenance.

The type of bevel tie is no more difficult to renew than standard ties on tangent, aside from the necessary countersinking of bolts.

The superelevation being calculated in the usual manner, the bevel tie, Fig. 1, is sized so that the thickness under the inner rail is 6 ins., the grade line being carried on this rail. The position of the hook and button head bolts is carefully noted with reference to the position of the tie over the girder, and their length is determined with reference to their position on the tie, countersinking where necessary to give uniform seat for guard rails. Care is taken not to have countersunk bolts under the running rail.

With curves on these roads ranging from 160 to 4,000 ft. radius, and with a uniform speed of 35 miles per hour, it is found that four types of these bevel ties, giving a superelevation of ⅞-in., 1⅞ ins., 3 ins. and 4½ ins., respectively, are sufficient to care for these curves. The sketch of bevel tie illustrates the extreme case of 4½ ins. superelevation. The various lengths of hook and button head bolts are reduced to six lengths and the lag screws to three lengths.

Where in reconstruction it is found necessary to intersperse new girders with old, owing to changes in alinement, it is necessary to use the standard 6-in. tie with a superelevation block, as shown in Fig. 2; these, however, are to be avoided wherever possible.

The ties were made 9 ft. 6 ins. long to cover varied spacing of stringers and to carry the electric contact rail. Run-off from curves is taken care of by notching each tie over girder to conform in length to 1 ft. for each eighth of an inch in superelevation of the curve.

The finished track presents a very orderly appearance and the proper inclination is given to the inner as well as the outer rail, resulting in a very uniform, vertical wear on both.

Yours truly, W. F. Graves,
Asst. Engineer, South Side Elevated R. R. Co.

4403 Indiana Ave., Chicago, Ill., July 29, 1904.

Sir: Referring to your comment in issue of July 21 on question of G. H. Holmes, relative to practice of giving superelevation to girder bridges on curves: Nearly all bridge specifications which we have noticed call for special bracing where the bridge is placed on curve; but we believe the best practice of superelevation the track on girder bridges is to incline the girder by putting special elevation castings under the girder, so as to leave ties all the same thickness. Of course there are special cases where this cannot be done, e. g., where a bridge comes on a spiral where the superelevation is not a constant throughout the length of the bridge. Some roads incline the girder by building the bridge seat on an incline.

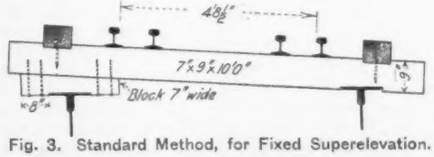



Fig. 3. Standard Method, for Fixed Superelevation.

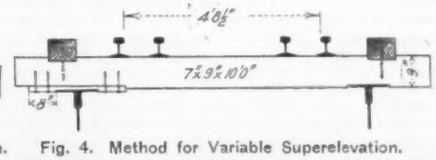



Fig. 4. Method for Variable Superelevation.

FIGS. 3 AND 4. SUPERELEVATION ON DECK GIRDER BRIDGES BY BLOCKING. PRACTICE OF PITTSBURG & LAKE ERIE R. R.

This is objectionable, as any shift of track changes the elevation of the bridge. Yours truly,

R. B. Ketchum,
Division Engineer, Oregon Short Line R. R. Co.
Pocatello, Idaho, July 25, 1904.

Sir: Referring to the inquiry of Mr. G. H. Holmes, in your issue of July 21, as to best method of placing superelevation in deck bridges on curves, I enclose herewith two sketches illustrating the practice of our road covering this point.

As shown in the first sketch (Fig. 3), a wooden block of sufficient thickness to give the curve its proper elevation 7 ins. wide (the full width of cross tie) and 16 ins. longer than the full width of cover plate or flange of stringer, is securely spiked to the bottom of each tie. Holes for spikes are bored through these elevation blocks to prevent splitting. The blocks are dapped ½-in. over the cover plate or the flange of the stringer, as also is the cross tie under the low rail.

In the event of the curve originating on the bridge, where the superelevation runs from zero to proper elevation, the method illustrated in Fig. 4 is employed. Ties are dapped to receive a block 2 ins. by 7 ins., by proper length, dapped ½-in. for cover plate or stringer. These are used until the dap in crosstie runs out, when we return to method illustrated in Fig. 3.

In short I-beam spans the superelevation is made in the bridge seat. Yours truly,

R. P. Forsberg,
Assistant Engineer, Pittsburg & Lake Erie R. R.
Pittsburg, Pa., July 30, 1904.

## Design for a Reinforced Concrete Column Without Patented Features.

Sir: There is a tendency to regard the field of re inforced concrete as quite monopolized by the firms using certain "systems" or patented bars, when equally as good results may be obtained by the use of simple structural shapes. The enclosed sketch for a concrete-steel column designed by the writer gives point to the foregoing.

The angles at the corners effectually prevent lateral flexture, and should be properly proportioned to resist the moment due to eccentric loading. An effective bond is secured by the introduction of the wire ties, which serve also to bind the column together and to resist the shear.

The angles at the center may be omitted if the load be not too heavy to exceed the crushing strength of the concrete, or may be made as heavy as desired, since the concrete supports it in such a manner as to secure the full crushing force of the steel. The batten plates, together with the rivet heads, form an excellent bond.

A column 16 ins. square, of 1:2:4 stone concrete, corner angles 2 × 2 × ⅝ ins., and center angles 3 × 3 × ½ ins. will carry a load of 117 tons up to a length of 16 ft. The cost of this perfectly fireproofed column will be about $2 per foot. The cost of a steel column of the same capacity will be about $2.28 per foot, without fireproofing.

To the knowledge of the writer no feature of this column is covered by a patent. If so, he would like to hear of it. Chas. H. Marquess.

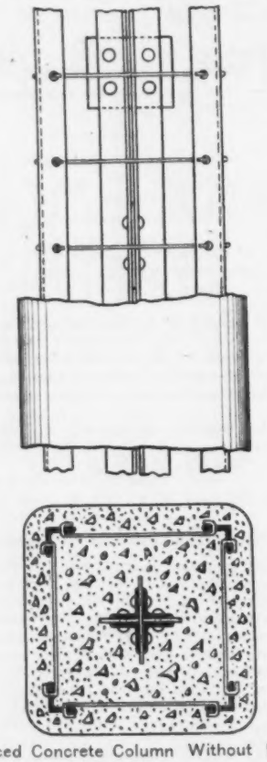
44 Church St., Charleston, S. C., Aug. 4, 1904.

## Trouble Over the Width of Pavements, Athens, Pa.

Sir: I have read with a great deal of interest during the past year your valuable articles on the width of pavements; and, as chairman of the Street Committee of Athens, having in charge the paving of nearly a mile of 50 and 60-ft. streets in the residence section of this borough, I decided to call in the borough surveyor and have measurements taken of the actual width of roadway in use on the streets to be improved. I found that it is 28 ft., and in some special cases it runs to 30 ft. from out to out of wheel tracks. Having a single-track electric line running through the center of the street, I decided on a width of 32 ft. between curbs, which gives a width of 11 ft. 8 ins. in the clear on each side of the car line, the largest electric car being 8 ft. 8 ins. over all. I considered two driveways of 11 ft. 8 ins. ample for a borough of 4,000 inhabitants, with a possible growth to 8,000 in the next 30 years, and having a farming community trading here from a radius of some ten miles.

Work of placing the combined concrete curb and gutter for some 2,000 ft. north of an existing pavement went on without much opposition from the residents in that section; but, on the staking out of the curb and gutter lines in the South Main St. section, where reside the well-to-do and retired business men of the town, they were up in arms at once, and appeared before the council demanding a 38-ft. driveway, claiming that their wives and daughters would be in danger of their lives every time they drove through this 32-ft. street, and that it would drive the farmers to other towns to trade, and that it would be impossible to bring a load of hay to town. Such utterances as these came from bankers, lawyers and business men in their speeches before the council. In spite of the influence of these men, I was able to keep the council with me, and we voted down their request by a vote of 6 to 2, and then made them a proposition to put in the extra width of pavement provided they would stand the expense of same. Their next move was to take council with an outside attorney, who very properly advised them that if they wanted additional pavement over what the rest of the citizens were getting, the proper way was to pay for it. They then demanded that the borough pay for the extra width of paving in front of two churches, public library and school building, amounting to some $89. This the council refused to do, and after six days of wrangling they were finally able to give bonds to the borough for payment of $1,076 inside of 30 days, to cover the cost of additional pavement, which they cut down to a width of 36 ft., after they had canvassed the property owners for subscriptions.

Our pavement is being laid by a general tax levy, and the available fund for paving nearly a mile of brick and concrete macadam, and building a dike along one of the rivers, containing some 10,000 yds. of fill, and a hose house for new volunteer fire company in the Fourth Ward, was $37,500. It was the limited amount of money at hand and the great length of street that needed to be improved that decided our width at 32 ft., and having also in mind the maintenance expense for such an amount



Reinforced Concrete Column Without Patented Features.

of pavement. This experience has proven to me how hard it is to satisfy those that want the street the width "our fathers made them," and kick because the innovation violates the "good old way," as mentioned by Mr. S. Whinery in his letter of Sept. 21, 1903.

I would like to have you state through your columns whether you consider the width of street adopted sufficient; also submitting the case for discussion by your readers. Yours respectfully,

David A. Keefe, Engineer.

Athens, Pa., July 30, 1904.

(There can be, we think, little doubt as to the propriety of paving for a width not greater than 32 ft. under the conditions stated by our correspondent. Indeed, a pavement was designed and built by a member of our editorial staff, giving only 9 ft. space between the curb line and the side of a passing trolley car; yet in spite of the fact that farm products, including large loads of hay, are hauled over this pavement, there have been no accidents and no complaints about undue narrowness. At first, it is true, horses are apt to be frightened by the passing of a car near by, but with a 9 ft. clear roadway there is at least 3 ft. clearance between the near side of a horse and a passing car, even when two horses are driven abreast—with a single horse the clearance is greater.

There are, in almost every large city, miles of streets not more than 36 ft. wide between curbs, yet having two car tracks down the center of the street. A better arrangement of car tracks, however, and an arrangement that materially reduces the cost of paving residential streets upon which two tracks are laid, is to place one track on each side of the pavement on a berm between the curb and the shade trees. This arrangement may be seen on several streets in Rochester, N. Y., which are notable for their fine appearance in spite of the existence of trolley tracks. The opposition to this arrangement of car tracks was very great on the part of many residents, the main argument being that the danger of being run over by cars was thus made greater; but experience has proved the danger to be imaginary, and now it is claimed by many residents that the danger of accidents is much less where car tracks are not laid between curbs, but upon the sides of the street.

It is always pleasanter to drive in the center of a street that has a sharp crown, for then the seat of the vehicle is not tilted as in driving along the curb. Moreover, there is less concentration of wear when there are no car tracks in the center of the street, hence a pavement lasts longer when car tracks are laid outside the curb lines. Of course, when the business section of a village is reached, the car tracks should leave the sides of the street and run down the center.

One of the best ways to convince residents that a design of street novel to them is nevertheless a good design, is to take a committee representing the "kickers" to visit a city or village where they can see for themselves the successful working of the so-called novel plan.—Ed.)

## Notes and Queries.

The article on Railway Location in Victoria, Australia, published in our issue of May 12, 1904, should be corrected, as follows:

The diagram on p. 460 should change places with the diagrams on p. 464. The title of diagrams of capitalized "Rise and Fall" should read. "Diagrams showing permissible expenditure to reduce Rise and Fall." The title of the diagrams as printed on p. 464 is the correct title of the diagram printed on p. 460.

AN ELEVATOR ACCIDENT caused the death of two persons in New York City on Monday, Aug. 15, 1904. A freight elevator in the ten-story building at 270 Mercer St. was being used, temporarily, for passenger traffic. When taking up a load of some twenty men, it got only as far as the second floor and there stopped and began to go down. It reached the bottom without material shock. The elevator man, suspecting that the mechanism was out of order, opened the door to let out the passengers. Just then the counterweights came down the shaft, broke through the roof of the car, and fell on the passengers. The elevator operator had just been able to get out of the door. None of the passengers escaped uninjured. One was killed outright, while another died shortly afterward. A third is believed to be fatally injured. The elevator was a Sprague Type Z electric drum machine. It had two sets of counterweights, car and back-drum, one above the other. The accident was caused by the car counterweights catching and lifting the back-drum counterweights into the overhead work, and thereby tipping off several counterweight sections, which fell down the shaft. The accident is under investigation.

THE EFFICIENCY OF ROTARY PRESSURE BLOWers, known as blowers of the Roots type, is the subject of a recent communication in the journal "Stahl und Eisen." The Adolph Meyer Machine Works of Aerzen, Germany, state that their blowers, which are of the Roots type, were tested by the Mechanical Laboratory of the Charlottenburg Technical College, with results as follows:

| Pressure in inches, water. | Power required in HP. | Volume delivered in cu. ft. per min. | Volumetric efficiency, %. | Speed r. p. m. | Power equivalent of delivered air in HP. | Mechanical efficiency, %. |
|---|---|---|---|---|---|---|
| 15.75 | 3.45 | 1,120 | 96.4 | 403 | 2.68 | 74.8 |
| 19.7 | 4.34 | 1,110 | 95.3 | 403 | 3.19 | 73.7 |
| 23.6 | 4.86 | 1,115 | 95.3 | 403 | 3.85 | 79.3 |
| 27.6 | 5.25 | 1,100 | 93.0 | 403 | 4.35 | 82.8 |
| 31.5 | 5.89 | 1,080 | 91.0 | 405 | 4.86 | 82.5 |
| 35.4 | 6.45 | 1,085 | 90.4 | 405 | 5.47 | 85.3 |
| 39.4 | 7.31 | 1,065 | 88.8 | 403 | 5.89 | 81.0 |
| 43.4 | 7.92 | 1,065 | 88.8 | 407 | 6.49 | 82.0 |
| 47.3 | 8.50 | 1,040 | 86.1 | 406 | 6.93 | 81.5 |
| 51.2 | 9.12 | 1,045 | 83.9 | 405 | 7.49 | 83.2 |
| 55.1 | 9.61 | 1,000 | 83.5 | 398 | 7.69 | 80.5 |
| 59.1 | 10.52 | 1,015 | 85.0 | 398 | 8.40 | 80.0 |
| 63.0 | 11.07 | 1,010 | 83.4 | 401 | 8.88 | 80.3 |
| 66.9 | 11.83 | 1,010 | 82.8 | 403 | 9.38 | 79.4 |
| 70.9 | 12.63 | 1,010 | 82.1 | 403 | 9.86 | 78.0 |
| 74.8 | 13.12 | 1,010 | 82.0 | 402 | 10.37 | 79.0 |
| 78.7 | 13.81 | 985 | 79.7 | 403 | 10.67 | 77.0 |

*Including countershaft.

Apparently these tests were all made on one and the same machine.

# ENGINEERING LITERATURE

Supplement to ENGINEERING NEWS. New York, August 18, 1904.

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One of the most notable gaps in American technical literature is in the field of gas engineering. There is practically no American book on the manufacture and distribution of gas for light and power or on any phase of either. So notable was this deficiency a few years ago, and more particularly the lack of technical instruction in gas engineering and gas works operation, that the American Gas Light Association established an educational fund and a correspondence school. The instruction papers for the pupils enrolled in this school come nearer, we believe, to an American treatise on gas works than anything else in existence, but those papers are available for enrolled students only. It hardly seems possible that so serious a deficiency as this could continue to exist much longer, particularly since a gas engineer of international reputation recently became the head of one of our leading technical schools.

Some time ago an engineer appealed to the editor of Engineering News for help in solving an algebraic formula involving logarithms. He had obtained a computed result which was quite evidently in disagreement with the facts. The formula used was derived by calculus integration, and the logarithmic term which it contained had reference, therefore, to hyperbolic or natural logarithms. On inquiring whether this had been taken account of, it developed that ordinary Briggs' logarithms had been used in the computation. When the proper reduction factor was introduced into the logarithmic term, so as to convert the Briggs into natural logarithms, the formula gave the correct desired result. Of course the little slip which this engineer had made was quite natural. Few engineers have occasion to use natural logarithms as often as once a year, and in most cases when using a formula they approach a logarithmic term with no thought of other than Briggs' logarithms. In the study of calculus it becomes perfectly clear that all logarithmic functions derived by integration refer to natural logarithms, but this fact is sometimes forgotten by the student even before his calculus course is completed.

It would seem proper that all books or parts of books which explain logarithms should make special note of the fact that natural logarithms, exclusively, are used in the calculus, and that when a logarithmic term appears in an engineering formula it must be computed by natural logs. On another page, in reviewing a little text book on Logarithms, we remark on the fact that the chapter on natural logarithms contains no definite suggestion of the reason for the existence of such logarithms, and no reminder of their appearance in integrated functions. The same lack appears in all other texts on the use of logarithms which have come under our observation. We write this in the hope that the writers of future text books of this sort may include at least a word to remind the reader where and why natural logarithms occur.

In the address by Mr. J. A. L. Waddell on a "Higher Education for Civil Engineers," noticed elsewhere in this issue, one of the functions of the members of the faculty of a suggested post-graduate school of civil engineering is thus stated:

> They should prepare a work discussing engineering literature that would include all technical books which are in accord with current practice, show their scope, and indicate their good and bad points. This treatise should be rewritten from time to time so as to keep it up to date.

The idea, by whomsoever carried out, certainly has much to commend it. The task would involve an examination of a vast mass of technical literature to learn what to reject and what to accept for discussion. This done, a virtual review of each book would be required. Every new book would necessitate the same general operation, so the task would be never-ending. Then, too, the profession would be benefited quite as much, and on the whole perhaps more, by having made available reviews of books *not* "in accord with current practice," since such books do not die easily and are capable of doing immense harm.

Another suggested duty of the professors of such a school would be

> to study current engineering literature, and to excerpt therefrom and deliver in the form of lectures everything likely to be of real value to the students, as well as to call their attention to the articles which each one ought to read. They should also teach the students the knack of reading current technical literature so as to obtain its gist with minimum effort and loss of time.

If we mistake not, exactly the use indicated is already made of engineering literature by the professors in our best engineering schools, but in many cases overwork prevents the fullest utilization of the material at hand. Much would certainly be gained if the students, as well as the professors, were called upon to make digests of engineering literature. Such digests could be made to serve the secondary but important purpose of training in the use of English by having them revised by a competent professor or instructor of English composition. This should be considered as supplementary to and not as a substitute for the more extended instruction in English advocated by Mr. Waddell in his address.

Still another duty of the permanent staff of the proposed school would be

> to translate or assist in the translation of all engineering books in foreign languages, which, in the opinion of competent experts, would prove useful to American engineers or to the students of the institution.

This proposition is worth considering, but a pretty large staff would be required for such work alone, and a larger one still if, as of course would be the case, the member of the staff engaged in making translations had other important duties to perform. Where would the men competent to make such translations be secured if another suggestion in the address were carried out: that time might be gained in many engineering schools "by omitting unnecessary studies from the curricula, notably the foreign languages"? To our mind, the higher engineering education will demand more rather than less study of foreign languages, and the high-class post-graduate schools of the future will require as one of the conditions of entrance a good reading knowledge of both French and German.

Owing to variations in the dates of closing municipal reports some hundreds of such public documents are always in preparation. It is never untimely, therefore, or will not be until great improvements in these reports have been made, to call attention to some of their defects and lost opportunities. The most common defect, which is also a lost opportunity, is a failure to present the information needed by the average intelligent citizen to enable him to judge the efficiency of any given department. The data required to this end almost always lack some essential features, the most common ones being the omission of one or more elements of cost and any proper basis of comparison. Thus capital charges will not be stated, or only the interest on the outstanding debt will be given, with no intimation as to total cost, depreciation and the like. Or the operating expenses of one department will be mixed up with those of another. The absence of a proper basis of comparison includes not only meager financial and physical data for a given year, but also a lack of similar data for previous years and for other municipalities. The latter deficiency, obviously, would or might soon disappear if each city or town made a complete exhibit of its own operations and conditions.

As is well known by all who have given the matter much attention, a large percentage of municipal departmental reports consist chiefly of a more or less perfunctory account of the routine work of the year, an abstract of receipts and expenses, which is generally little more than a cash account, some incomplete descriptive statistics, and perhaps an inventory of tools or other property on hand. Happily there are marked exceptions to this characterization. An increasing number of reports review the work of the year in an instructive manner, accompanying the text with half-tone views and less often with reproductions of line drawings, at the same time giving figures of both capital and operating expenditures.

Municipal reports, in the aggregate, form a huge volume of literature which may be of great service to both the municipalities issuing them and to other cities and towns throughout the country. To be of the greatest value, both local and general, they should be not only complete in essential details, but should aim at uniformity of statistical statement from year to year and from city to city. To this end we commend, in matters of accounting, the schedules proposed by the National Municipal League, of Philadelphia; for statistics of public works, the schedules of the New England Water-Works Association, Tremont Temple, Boston, and of the American Society of Municipal Improvements, Municipal Building, Brooklyn, N. Y.; and for vital statistics the classification adopted by the U. S. Census Bureau. The Bureau has also interested itself in the whole subject of statistics of cities, and doubtless it would gladly offer suggestions to any municipal official who wished to increase the usefulness of the annual reports of his department.

### Census Bulletins on Estimating the Population of Cities.

Engineers are often called on for estimates of the population of cities, and nearly as often find it a perplexing task. Two bulletins on this subject published by the U. S. Census Bureau, may well be added to the library of every engineer who has not yet obtained them. One bulletin discusses the general subject of estimating population, advances a simple method for that purpose and gives statistical and other evidence in support of it. The other bulletin, which was noted briefly in this Supplement for July 14, 1904, contains estimates of population for the three years, 1901, 1902, and 1903, for the 438 cities of the United States which in 1900 had populations of 10,000 or over. These estimates are arranged alphabetically for all the 438 cities, and again alphabetically by States. The tables include, for each city, the census populations for 1890 and 1900, the decennial increase, estimates for the three years mentioned, the area of each city in acres and the area annexed since 1890. The population on territory annexed since 1900 is included in the estimates, and enquiry has been made of local officials to determine whether special influences have affected the population. It will thus be seen that

the Bulletin (No. 7, 1904) is a most useful one. Opportunity for discussion is afforded by the method employed in making the estimates, which is briefly stated in this bulletin and more fully in the earlier one already mentioned. (Bulletin No. 135, Jan. 30, 1902.)

The plan adopted is the arithmetic rather than the geometric. That is, to obtain the population in 1901, one-tenth of the increase from 1890 to 1900 is added to the population of 1900. In arriving at the conclusion that this was the best method to be employed, tables were made up for cities of 50,000 population and upwards, based on percentage of increase of population from 1890 to 1900 and from 1880 to 1890, on total votes cast at elections, on school censuses and on the number of names in city directories. The conclusion was that none of these methods gave results which came so closely to the actual or census populations as the simple arithmetic method. It should be noted that all the tables presented compare estimates for ten years of increase with the census obtained at ten-year intervals, and that there is no available means of checking estimates for inter-census years. It would have been interesting, and might have been instructive, if the study included a score or two of cities of 10,000 to 15,000 inhabitants.

The plan pursued by the Census Bureau has the great merit of simplicity, and it is doubtful whether it could be surpassed for making estimates for a group of cities. For individual cities most engineers, and probably the census officials as well, would wish to check any method of estimating population by all the other methods that could lay any claim to value. The population curve ordinarily used by engineers, it may be added, differs from the Census Bureau method in that it takes a series of decennial census periods as a basis and projects the curve thus obtained through one or more additional ten-year periods. The Census Bureau forecasts for ten years only, and bases its forecast wholly on the growth of the last preceding ten years.

Of the 463 cities in the latest of these two bulletins, 163 annexed territory between 1890 and 1903, and no less than 59 during the years ending June 1, 1903. In many cases the population of the annexed territory was doubtless small (no figures bearing on this are given). Such instances as New York City are extreme illustrations of the necessity of taking annexation into account. Of New York's present area of 209,218 acres, a total of 182,863 acres, including thereon so large a city as the former Brooklyn, have been annexed since 1890. No law has yet been deduced for estimating growth by annexation, but the figures already cited indicate that such growth is on the increase.

The bulletin on "Methods of Estimating Population" was prepared by Prof. Walter F. Willcox, of Cornell University, who served as Chief Statistician for Methods and Results. It is to be commended for showing how not as well as how to estimate populations.

## CORRESPONDENCE.

### The Need for Indexes of Engineering Literature.

Sir: Your timely discussion of the question of indexing engineering literature, in your issue of July 14, was read with much interest by the writer.

A member of no profession to-day labors under such serious disabilities in obtaining recent information in matters relating to his profession as does the practicing engineer. The great mass of very valuable information which appears in the current engineering periodicals is not readily accessible, because it is not indexed up to date, either in publications, or by any of the engineering libraries. The engineer must either go to the expense of keeping an index himself or spend weary hours digging into records whenever necessity for investigation occurs. This is time wasted which could be much more profitably employed in the actual investigation.

The index published by the "Engineering Magazine" has been extremely useful to the writer, but unfortunately the bound volumes of the index go no further than the year 1900.

The writer believes that no more profitable and useful work could be done by the national engineering societies for the benefit of their members than by combining in getting out a card index of current engineering literature.

Yours truly, E. W. Stern.

7 West 38th St., New York, July 21, 1904.

### The Practical Side of Boiler Construction.

Reviewed by G. R. Henderson,* M. Am. Soc. M. E.

BOILER CONSTRUCTION.—By Frank B. Kleinhans. New York: Derry-Collard Co. Cloth; 5 × 8 ins.; pp. 421; many illustrations in the text. $3.

As the name signifies, this work treats of the mechanical methods of constructing boilers and touches but slightly on the theoretical side of the subject. As a matter of fact, the whole work is confined to the locomotive boiler, no space being allotted to other types, excepting a mere reference in the preliminary chapter.

The book starts with a description of the method of laying out gusset sheets, but the author has not succeeded in making this as clear as he might have done, although the illustrations are good. In fact, the explanation is almost too brief where it should be very full in order that the mechanic might understand fully the methods to be followed. After various styles of gussets, the other sheets are discussed, generally in quite a clear manner. The writer lays particular stress upon continually checking up the work as the laying-out progresses. The difficulties of the outside throat are enumerated, not only of the ordinary type, but also of the Wootten boiler, and instructions given for overcoming same. The next chapter, on flanging, is particularly interesting on account of the illustrations and suggestions in connection with using the modern flange press. Valuable hints are also given regarding the most difficult shapes to form. These will be found very useful to those installing power flanging presses, as the available literature on this subject is limited.

In his description of punches some novel designs are shown for cutting along irregular lines or for trimming edges, which are available for any boiler shop. The subject of bending by rolls is fully treated, as well as a special way of using the rolls as a bending press. Various forms of drills and cutters are shown and the method of using them explained. The portion on riveting discusses the method of swinging the shell in order to easily perform the different operations, and the advantages of the several varieties of power riveters are considered.

Stays and stayed surfaces come in for a fair treatment, and the methods of applying the stays to the shell are fully described. A dozen pages are devoted to steam connections, and as many more to the various fittings applied to the boiler. The chapter on assembling contains some very good suggestions, especially in connection with calking tools and the method of keeping them to correct shape, but only three pages are devoted to setting tubes, which seems entirely inadequate considering the importance of the subject and the great difficulty of maintaining tight flues in locomotives. It is a pity that this did not receive more generous treatment. Forty-five pages are given to illustrations and descriptions of up-to-date boiler shop machinery. This section is followed by tables of general information needed in planning and constructing boilers. It seems odd, however, that these tables do not include the shearing value of rivets of different sizes and with various unit stresses, as data for strength of bolts and pins are given at considerable length. A fair index is supplied, but the pages are very awkwardly numbered at the bottom, instead of in the conventional upper corners. On the whole, the work is admirable, and fills a long-felt want. The illustrations are clear and numerous, there being upwards of 300 in the text, besides half a dozen large drawings of boilers on folded sheets at the end. The book can be commended highly to journeymen and apprentice boiler makers who wish to make themselves proficient in their trade. The drawing office will find it very useful in making bills of material and studying simplicity of construction.

NATIONAL ASSOCIATION OF MANUFACTURERS.—Proceedings of the Convention Held at Pittsburg, Pa., May 17 to 19, 1904. Marshall Cutting, Secretary, 170 Broadway, New York City. Paper; 6 × 9 ins.; pp. 254.

A large part of this report is taken up with a discussion of various phases of union labor problems.

*Consulting Engineer, 20 W. 34th St., New York City.

### A Greatly Improved Edition of a German Book on the Steam Turbine.

Reviewed by Prof. Storm Bull,* M. Am. Soc. [illegible]

DIE DAMPFTURBINEN.—Mit einem Anhange über die Aussichten der Warmekraftmaschinen und insbesondere der Gasturbine. By Dr. A. Stodola, Professor at the General Polytechnic School at Zürich. Second greatly enlarged edition. Berlin: Julius Springer. Cloth; 9 ins.; folding plates and 241 figures in the text.

The first edition of this book† created a good deal of attention, as is witnessed by the fact that it was sold out in a very short time. It was then unquestionably the best book on the subject of steam turbines, and the new edition adds greatly both to the usefulness of the book and to the reputation of the author. In all directions the work has been made more complete, especially, however, in the practical line of description of the various kinds of turbines now made, which descriptions are all accompanied by excellent detailed drawings of the various parts. How complete the book is in this direction can best be seen from the list of the names of turbines considered: De Laval, Seger, Riedler-Stumpf, Zölly, Curtis, Rateau, Parsons, Schulz, Lindmark and Gelpke-Kugel. A very large amount of experimental data with respect to the performance of these turbines is also given and the advantages and disadvantages of the various types are discussed in a thoroughly unprejudiced manner.

The theoretical part of the book, both with respect to the flow of steam through nozzle and buckets, and as to the strength of disks and shafts has also been greatly enlarged and forms perhaps the most valuable part of the volume.

The announcement that the book is soon to be published in an English translation ought to make many feel happy, as there is no book on the subject at the present time which can at all be compared with this one in either completeness or thoroughness.

HILFSBUCH FUR DEN MASCHINENBAU.—Für Maschinentechniker sowie für den Unterricht on technischen Lehranstalten. By Fr. Freytag. Berlin: Julius Springer. Cloth; 6 × 8 ins.; pp. 1,008; six folding plates and 867 figures in the text. $4.

There are enough good mechanical engineers' handbooks in the English language that we need not have recourse to German handbooks. On this account the work here noted is of relatively little interest to American engineers. It is a good work of its kind, and as against similar American books, it is noteworthy for the excellence of its typography as well in selection of type as in execution, and for the clearness of its line drawings. The views (wood cuts) which appear here and there, where it was desired to illustrate some descriptive portion, are less admirable. A feature which is unusual for books of this kind is an appended chapter wherein the principal elements of structural work are discussed in condensed form: walls, timber framing, floor constructions, wooden and steel roofs, etc. But this chapter is hardly up to a thoroughly modern level, and (at least for American conditions) should be thoroughly rewritten.

LOGARITHMS FOR BEGINNERS.—By Charles N. Pickworth. London: Whittaker & Co. New York: D. Van Nostrand Co. Limp cloth; 5 × 7½ ins.; pp. 47; tables. 50 cts.

This little instruction book contains all the information necessary for a good understanding of logarithms. It explains the "index law," shows how logarithms are based on this law, describes the various artifices used in logarithmic expression (for example, the use of a negative characteristic with a positive mantissa in the logarithm of a fraction), and gives numerous examples by which the student may obtain some illustrative practice in logarithmic computation. Such terms as antilogarithm and cologarithm are also explained. A short table of four-place logarithms and antilogarithms is given at the back of the book.

The path followed in the explanation of the principles of logarithms is, to our personal taste, somewhat peculiar; but perhaps no similar work meets the approval of everyone. It is sufficient to say that the logic is correct at all points, and

*Professor of Steam Engineering, University of Wisconsin, Madison, Wis.

†Reviewed by Professor Bull in this Supplement for Jan. 14, 1904.—Ed.

contains no gaps to cross which would require the assistance of a teacher.

At the close of the explanatory matter is given a short statement of the nature of natural logarithms and a demonstration of the method of converting logarithms from one system to another. In connection with (so far as we know) all other books explaining the nature of logarithms, the chapter on natural logarithms has the fault of not telling why this system of logarithms is required for certain calculations.

## A Practical and Scientific Treatise on British Refuse Destructors.

REFUSE DISPOSAL AND POWER PRODUCTION.—By W. Francis Goodrich, Assoc. Inst. M. E. New York: E. P. Dutton & Co. Cloth; 6 × 9 ins.; pp. 384; 98 illustrations, mostly in the text. $5 net.

The production of power from municipal refuse has now become so common in Great Britain as to warrant a book devoted to the subject. The book before us is neither a theoretical discussion nor the work of a theorist. It is a scientific discussion of the practice of the day, written by a mechanical engineer who represents one of the most prominent British manufacturers of refuse destructors. This discussion is supplemented by statistical and other descriptive matter relating to a large percentage of the refuse destructors in Great Britain and also in other countries of the world, except the United States. Destructors are included in the descriptive matter, it should be added, regardless of whether or not the heat from them is utilized for power; nor is the scientific discussion confined to destructors combined with power production.

Mr. Goodrich will be favorably remembered by some of our readers as the author of "The Economic Disposal of Towns' Refuse" (London and New York, 1901; reviewed in Engineering News of Sept. 19, 1901). The present volume may be considered as supplementary to the earlier one, rather than a substitute for it, and yet is complete in itself. The earlier volume possesses advantages over this one for those wishing to study makes of furnaces, but the later volume is decidedly the better of the two for all who wish to study types rather than makes. It should not be understood, however, that the present volume fails to present sufficient data to aid one in passing judgment on different makes of furnaces.

After discussing what he considers to be the defenceless practice of dumping refuse on land or at sea, the author presents an enlightening chapter on "System of Charging Refuse into Cells." These systems include top, front and back hand feed and automatic top feed. Many American readers will be surprised to learn that anything except top feed is employed in Great Britain, and more surprised still to learn that the author strongly favors hand or shovel feeding through doors at the front of the cells. By this method, it is urged, the refuse is put exactly where wanted without further pushing or pulling. The author claims that this practice involves less labor, less coaling of the fires, and a more active continuous fire than any of the others.

Having explained the methods of charging and the merits and demerits of each, it is an easy step to describe the different types of British destructors. Both this and the preceding chapter are illustrated with sections of destructors.

The chapter on labor cost is valuable, but it would be more so if labor cost in Great Britain really included all the labor required for the destruction of refuse. As it is, labor cost means only feeding the refuse into the cells and removing the clinker from the grates. Engine men, repair men, and the force required for the final disposal of the clinker are not included in labor cost. The comparison of the combined wages of chargers and stokers, separate from all other labor charges, is eminently desirable, but it tells only a part of the story.

A brief chapter on clinkering is followed by a longer one on the final disposal of residuum, with special reference to the utilization of clinker for making mortar, paving slabs and brick. The next three chapters deal with refuse destructors combined with electricity works, sewage works and water-works. Here again American readers who are not keeping close track of what has been done in Great Britain will be surprised to learn how common it has become in that country to combine refuse destructors with entirely independent works for which power is required. It is taken for granted that the heat from the destructors will be used at least for "works purposes"; that is, for producing forced draft and for driving mortar mills and slab making machinery.

After a few pages on "Destructor Sites," which, we are told, should minimize cartage and provide for the fullest possible utilization of power, the author takes up the relative advantages of steam jet blowers and fans as means of producing forced draft, special points conducing to high furnace temperatures and the comparative merits of various types of steam boilers.

The last half of the volume is devoted to descriptions, mostly statistical, of refuse destructors in use throughout the world. Most of this space, naturally enough, is occupied with destructors in England, Wales, Scotland, and Ireland. For each of these destructors the author gives, as far as possible, its date of erection, make and type, number of cells, number and type of boilers, height of chimney, type of draft used, application of power developed, weight of refuse destroyed daily, labor cost per ton of refuse destroyed, the average number of Board of Trade Units generated per ton of refuse destroyed (when combined with electricity works), and whether the destructor is combined with electricity, sewage or water-works. The population of each municipality is also given. In many instances the result of official tests, some quite elaborate, of the destructors are given, and in some cases the installations are described by means of text and illustrations. For destructors abroad the author goes less into statistical and other details.

The section on destructors in the United States comprises fifteen pages, of which a considerable portion is given up to attempts to prove that bad as have been our garbage furnaces, as we call them, our reduction plants for the recovery of grease and fertilizing material are "on the whole quite as unsatisfactory." Considering that Mr. Goodrich is the London representative of a firm of manufacturers of British refuse destructors, one cannot but feel that he showed a remarkable freedom from bias in discussing different makes of British furnaces. This measure of impartiality, combined with the author's familiarity with the whole subject of refuse destruction, entitles his remarks on American garbage furnaces to serious consideration, but in the discussion of garbage reduction plants the author shows both the bias that might be expected in a promotor of refuse destructors and the broad and sometimes fallacious generalizations so likely to result from second-hand information. Even in the case of American garbage furnaces the author makes some slips, like saying that these, as well as reduction plants, are, "for the most part," operated by private companies under contract, whereas there are only one or two instances of such operation in the whole country. Mr. Goodrich also assumes that the composition of mixed refuse in England and America is essentially the same, which we believe is erroneous. There is both truth and fallacy, as well as occasion for amusement, in the two following paragraphs:

> To the British engineer it will doubtless be a source of satisfaction to know that in this particular branch of engineering we have nothing to learn from American design or practice.
>
> Likewise the British sanitarian must observe with pleasure the premier position of his own country, viewing with amazement the utter disregard of elementary principles of sanitary science shown by our kinsmen across the Atlantic.

No exception can be taken to the first paragraph, if its meaning be confined to refuse destructors. As to the second paragraph, the defects in our refuse destructors or garbage furnaces are not so much due to a disregard of the elements of sanitary science as to a failure on the part of municipal councils to recognize the fact that burning garbage and other refuse is an engineering question. British councillors, according to Mr. Goodrich, are slow enough to recognize the sanitary principles underlying refuse disposal, but when they are once worked up to the point of introducing destructors, they at least make a show of calling in the municipal engineer or surveyor. This our American councillors rarely do. In the final chapter, chimneys, the retention of dust, temperature observations and gas analyses are discussed.

One cannot but regret that the chapter on "Labor Cost" has not a companion one on capital, cost and depreciation. This is a sin of omission for which, in view of the difficulties and dangers besetting the subject, one can find an excuse. Two sins of commission, for which excuses are not so readily found are a diffuse and sometimes careless literary style and over-zealous and sometimes ill-chosen arguments for establishing destructors, based on assumptions that any other method of refuse disposal is necessarily a nuisance and a means of spreading disease. But the faults of the book are few and of a minor character compared with its merits. The latter are sufficient to class the book among the most valuable of recent contributions to engineering literature.

USES OF ELECTRICITY ON SHIPBOARD.—By J. W. Kellogg. With an Appendix on Small Lighting Plants for Launches. New York: Marine Engineering. London: E. & F. N. Spon. Cloth; 6 × 8 ins.; pp. 78; illustrated. $1.

The purpose of this book is stated in the preface to be,

> to satisfy a demand for thoroughly practical information regarding the uses of electricity on shipboard, so that the man who has not had special electrical training, but who is called upon to care for an electric plant, can prepare himself for the work.

But it would hardly do to put in charge of a ship's electric plant a man with no knowledge of the subject beyond that obtained by reading this book. The general features of typical electric light and power installations on board ship are fairly well covered in a descriptive way, but details are touched on only sparingly. In part this is accounted for by the fact that the book is a reprint of several articles which appeared in "Marine Engineering."

The first chapter reviews some of the earliest installations of electric lighting on ships. Then the generating plant, its engine and dynamo, are briefly discussed, with some remarks on the usually selected size and number of units. This descriptive chapter contains here and there some hints for the care and handling of the plant, but by no means sufficient to serve as instructions for operating. The usual characteristics of the distribution wiring and fittings are described in the next chapters. Then follows some discussion of electric auxiliary power, such as hoist-winches and windlass, and a few words on storage batteries. Lastly, a typical installation, for a 350-ft. passenger and freight steamer, is described. Two chapters headed "Appendix," contributed by Mr. D. A. Richardson, treat of the main features and usual arrangement of Small Lighting Plants for Launches.

HIGHER EDUCATION FOR CIVIL ENGINEERS.—An Address to the Engineering Society of the University of Nebraska, April 8, 1904. By J. A. L. Waddell, D. Sc., LL. D. Lincoln, Neb.: The Society. Paper; 6 × 9 ins.; pp. 21.

That a higher and better education for engineers is needed than that now being given by the engineering schools of the country, Mr. Waddell strongly believes. One of the interesting suggestions for improving engineering education is for the faculty of a technical school to launch "out ahead of the technical literature," and secure for the students "the latest information directly from practicing engineers." The deficiencies in the recent engineering school graduate include

> inability to express himself correctly and forcibly in either writing or speaking, lack of all ideas of system, inaccuracy in computations, ignorance of money values and economics, slovenliness in drafting, ignorance of what a drawing should contain to make it complete and serviceable, failure to understand the practical application of what he has learned in his technical course, and unacquaintance with numerous little practical things that he ought to have learned.

How to remedy this and other defects in the engineering graduate are discussed in turn. Among other things there are suggested the study of English throughout the whole course and the study of both political economy and economics; increasing the school year to eleven months, some

of which would be given to field work; five-year courses; and, to crown all:

Let one of America's multi-millionaires found and endow most liberally a post-graduate school of civil engineering, in which would be employed as officers, professors and lecturers men of the highest talent in the country, irrespective of what it may cost, and let the institution be established and equipped upon the broadest lines.

Some phases of the proposed work of such a school are discussed on the editorial page of this issue of the Supplement.

## The Fundamental Laws of Static Electricity.

Reviewed by Prof. Henry H. Norris.*

A TEXT-BOOK ON STATIC ELECTRICITY.—By Hobart Mason, B. S., E. E. New York: McGraw Publishing Co. Cloth; 6 × 8 ins.; pp. 155. $2.

In this book the author has separated from the mass of literature upon the subject the fundamental laws of static electricity, and he has arranged the material in convenient form for class work use and for reference. He begins by describing the general phenomena which form the basis of knowledge of this subject, and which lead to our conception of the electrostatic field. The treatment of the electrostatic field then occupies considerable space and includes the standard theorems relating to dielectric flux, electric potential, dielectric stress and tubes of force, all of which are given much as they appear in standard text books on physics.

Two interesting chapters are those devoted to electrostatic capacity and condensers. A few simple illustrations of capacity calculations are inserted in full and a number of different types of condenser are described. This section also includes a description of laboratory methods of measuring capacity.

The balance of the work is devoted to electrostatic generators and to instruments which either depend for their action upon the forces exerted between charges of electricity or which are used in connection with electrostatic measurements.

The book is as free from mathematics as is possible with this subject, and it is divided into numbered sections each of which is nearly independent of the remainder, although there is continuity in the treatment. The subject has been approached from the standpoint of physics rather than that of engineering, and very little reference is made to the practical applications which a knowledge of static electricity has made possible. For example, something could have been said which would have shown how to apply this knowledge in the solution of problems of insulation in overcoming the dielectric strains encountered in the operation of high pressure alternating current circuits. The importance of a correct understanding of this matter cannot be overestimated, for the success of electric power transmission depends largely upon insulation. The connection between static and current electricity is therefore very close, and for practical purposes the two must go together. In engineering the static strains are backed up by power while in scientific studies such as are covered by this text book the amounts of power developed are very slight. However, the book evidently covers the intended field, and for students approaching the study of electrical engineering from the scientific side, it will undoubtedly prove useful.

## The Theory of Reinforced Concrete.

TRAITE THEORIQUE ET PRATIQUE DE LA RESISTANCE DES MATERIAUX APPLIQUEE AU BETON ET AU CIMENT ARME.—Par N. de Tedesco, Redacteur en Chef du Journal "Le Ciment" et A. Maurel, Ingenieur-Constructeur. Paris: Librairie Polytechnique. Cloth; 7 × 10 ins.; pp. 640; 159 figures in the text. $7.50.

This volume is chiefly noteworthy for its collection in one place of the various theories that have been advanced to explain the action of concrete reinforced with metal. The first section, on the properties of cement and of cement mortars and concretes, is relatively brief, since these questions have already been treated in other French works that can be readily consulted. In the second part of the book, which comprises some 200 pages, the author gives in detail the theories of reinforced concrete that have been developed by Coignet, Christophe, Lefort, Résal, Harel de la Noe, Ritter, Melan, Von Emperger, Maurel, Considère, Hennebique and others. This collection is valuable in bringing together the vast amount of investigation and discussion that has appeared scattered through technical periodicals during the last dozen years. In the concluding section of the book the author discusses practical methods of calculation. Calculations for concrete steel in compression, tension, flexure and shear are discussed, and this discussion is followed by the presentation of simple formulas for slabs, beams, ribbed slabs, etc. An appendix gives the results of a large number of tests of concrete steel made by various authorities.

*Cornell University, Ithaca, N. Y.

DIRECTORY OF AMERICAN CEMENT INDUSTRIES.—Third Edition, Revised and Enlarged. Edited by Charles Carroll Brown, M. Am. Soc. C. E. Indianapolis and New York: Municipal Engineering Co. Cloth; 6 × 9 ins.; pp. 734. $5.

The present edition of this directory exhibits a number of changes from previous editions. It will be noted first that the technical matter contained in the two preceding editions has been separated from the directory proper, and is published by itself as a "Hand-Book for Cement Users." Practically the only technical matter now contained in the directory are the brief descriptions of cement plants, which occupy altogether only 94 of the 734 pages. The remainder of the book is devoted almost wholly to lists giving the names and addresses of cement manufacturers, dealers in cement, contractors and other users of cement, engineers, manufacturers of cement machinery, sales agents, and other persons connected directly and indirectly with the cement industry. For persons requiring a trade directory of the cement industry the present volume will be found exceedingly useful.

AMERICAN TRADE INDEX, 1904.—Descriptive and Classified Membership Directory of the National Association of Manufacturers of the United States, Arranged for the Convenience of Foreign Buyers. New York: National Association of Manufacturers. Cloth; 6 × 9 ins.; pp. 648. $5.

Although limited to the membership in the Association, and therefore very incomplete in some lines, this is nevertheless a handy directory of manufacturers. It includes an alphabetical list of members of the Association, with a statement of the goods made by each, a classified directory based on the goods made, and indexes in German, French and Spanish.

THE THEORY AND PRACTICE OF LETTERING.—Designed for the Use of Engineers and Draftsmen Generally, but Especially for the Use of Students of Engineering. By Christopher E. Sherman, C. E. Sixth Edition. Columbus, O.: Midland Publishing Co. Cloth; 8 × 11 ins.; pp. 49; 11 plates and also figures in the text. $1.

This book on lettering (now, according to the title-page, in its sixth edition, but, judging from the prefaces, in its third) has been added to from time to time, until it now forms a good working treatise, especially adapted for the use of students.

THE ADJUSTMENT OF THE ENGINEER'S TRANSIT AND LEVEL.—By Howard C. Ives, Assistant Professor of Civil Engineering, University of Pennsylvania. Philadelphia: The Author. Paper; 5 × 7 ins.; pp. 16; 10 figures in the text. 10 cts.

This is a good elementary work on the adjustment of transits and levels. The explanations are clear and concise, yet sufficiently full. While written primarily for students it should also be useful to practicing engineers.

AMERICAN CIVIC ASSOCIATION.—Bulletin No. 1. Rochester, N. Y.: Charles Mulford Robinson, Secretary. Paper; 6 × 9 ins.; pp. 4.

The consolidation of the American Park and Outdoor Art Association and the American League for Civic Improvement under the name of the American Civic Association is recorded in this bulletin. The constitution and officers of the new organization are given.

WATER-WASTE INVESTIGATIONS IN NEW YORK CITY IN 1903.—Reprint of Appendix IX. of the Report of the Commission on Additional Water Supply. New York: The Pitometer Co., 220 Broadway. Paper; 6 × 9 ins.; pp. 31; tables and illustrations.

Although reprinted and circulated for advertising purposes, it may be seen from the sub-title given above that this pamphlet is an extract from an official report. The water-waste investigations in question were made under the immediate direction of Mr. Edward S. Cole, by means of the pitometer, and also by means of house-to-house inspection.

The pamphlet is of value as describing the methods of the investigation, and presenting a summary of the data obtained, but its final con-

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clusion is a confession that certain details necessary to determine "where a majority of the large might flow goes to" are lacking. This is not so much a fault of the investigation as of the deficiencies, through many years, of the management of the distribution system of the water supply of the present borough of Manhattan.

## A German Text-Book on Hydraulic Construction.

Reviewed by Allen Hazen,* M. Am. Soc. C. E.

ELEMENTE DES WASSERBAUES.—Für Studierende Höherer Lehranstalten und Jüngere Techniker. By Eduard Sonne, Professor an der Technischen Hochschule zu Darmstadt, and Karl Esselborn, Professor an der Landes-Baugewerkschule zu Darmstadt. Leipzig: Wilhelm Engelmann. 6 × 9 ins.; pp. 337. 10 marks, or $4 in the United States.

This is a text-book of hydraulic construction. The German monographs in the various departments have become so numerous and filled with detail that a compact and comprehensive outline of the subject is needed for students in technical schools.

There are several chapters upon subjects which are well covered in American text-books, such as the construction of reservoirs, the flow of water and the structures for carrying it. But the book also treats of many other subjects, such as ground water and its flow, and of the works for its collection; of the training of rivers to improve navigation; of movable dams; of waterways, including the construction of locks; of the resistance to the movements of ships; and of the protection of shores of rivers and lakes and of the sea against currents, tides and waves. The work thus covers an extremely wide field in an elementary way, and a field which for the most part has not yet received the attention which it deserves in this country.

The numerous illustrations are clear, and without showing details serve to give an accurate idea of the principles which must be applied.

STANDARD PLANS FOR PILE AND TIMBER BRIDGES: A. T. & S. F. RY.—By A. F. Robinson M. Am. Soc. C. E., Bridge Engineer, A. T. & S. F. Ry. System. Bulletin No. 53 of The American Railway Engineering and Maintenance of Way Association; Secy., L. C. Fritch, 1562 Monadnock Block, Chicago. Paper; 6 × 9 ins; pp. 8; illustrated.

This bulletin contains seven plates of the railway company's standard designs for pile and timber trestles, and another plate with drawings of ballasted floor trestles. With these there is a general description of the plans. Although the title says "bridges," no truss bridges are shown, but only trestle bridges.

SANITATION.—A Monthly Journal of Hygiene and Sanitary Science. Official Bulletin of the State Board of Health of Pennsylvania and Associated Health Authorities and Sanitarians of Pennsylvania. Milner R. Batt, Editor and Publisher, P. O. Box 802. Philadelphia, Pa. Paper; 7 × 10½ ins.; pp. 45.

If any State in the Union is in more need than another of a journal devoted to sanitation that State is Pennsylvania. The first number of this new venture is largely occupied with papers read before the Associated Health Authorities of the State. On the whole, the publication is a creditable one, but the use of jokes and attempts at jokes for fillers detracts from the dignity of the journal.

THE FAR EASTERN REVIEW.—Published Monthly. Vol. 1, No. 1. Manila, P. I.: Geo. Bronson Rea, M. E., Publisher. Paper; 10 × 14 ins.; pp. 48; illustrated. $2.50 per year in the Philippines, United States, Canada and Mexico; other countries in the Postal Union, $3. Single copies, 25 cts.

It is announced that this new journal will be devoted to the engineering, commercial and financial interests of the Far East. The leading article in this issue is on the "Approved Water System for Manila, P. I.," by J. F. Case, Engineer-in-Charge. The sum of $4,000,000 has been appropriated for a new water supply and sewerage system.

THE LOWER ROXBOROUGH PRELIMINARY FILTERS.—By P. J. A. Maignen. Reprinted from the Proceedings of the Engineers' Club of Philadelphia. Philadelphia: Address the author, 1310 Arch St., Philadelphia, Pa. Paper; 6 × 9 ins.; pp. 46; illustrated.

The rapid filters (Mr. Maignen prefers to call them scrubbers) described herein are preliminary to slow sand filters, and consist of either furnace slag or coke below and sponge clippings above. Upward filtration is employed. The sponge clippings are removed, washed and replaced. Turbidity and bacterial results are given. Appended to the paper is the discussion which followed when it was read last April.

*Consulting Engineer, 220 Broadway, New York City.

GAS AND OIL ENGINE MANAGEMENT.—Practical Guide for Users and Attendants, Being Notes on Selection, Construction and Management. (By M. Powis Bale, M. Inst. M. E., Assoc. M. Inst. C. E. Philadelphia: J. B. Lippincott Co. London: Crosby Lockwood & Son. Cloth; 5 × 8 ins.; pp. 110; one figure in the text. $1.50.

The selection, installation, handling and operating of internal-combustion engines forms the theme of this book. Design and construction are not discussed, except very briefly, as they affect the user of the engine. It is to the engine-user, more especially to the user of stationary engines, that the author addresses himself. His purpose is carried out in a very satisfactory manner. The instructions and suggestions given are clear and practical. Much experience in installing and handling gas and oil engines has enabled him to point out the principal sources of trouble in such machines and to advise how troubles are to be avoided or remedied. Unlike most technical works of British origin, this book is in no way "foreign," but is just as well adapted to conditions in America as to those in England. Perhaps the rather weak treatment of electric igniters may be charged to the nationality of the book. Also, of course, a reference to the compulsory "guarding" of engines, under the Factory Act, is purely English, though the suggestions for guards are just as valuable in America, particularly the last one: "A guard rail should also protect the engine from casual visitors." A collection of tables and numerical data given at the end of the book, should prove convenient, though unfortunately several of the formulas seem garbled, by the use of addition for multiplication signs, and the like.

FINANCES OF GAS AND ELECTRICITY MANUFACTURING ENTERPRISES.—By Wm. D. Marks, M. Am. Inst. E. E. Philadelphia: The Author. Stiff paper; 5 × 7 ins.; pp. 125; 2 folding plates of diagram. $1.

While this little work does not pretend to be a technical treatise or text, being intermediate between this rank and that of advertising literature, yet it merits perusal by a great many men who have to do with public service enterprises; such as engineers and members of municipal commissions or boards. It presents much material that will induce thought on the financing, managing and operating of such enterprises, on the rates to be established, on the control to be exercised over the corporations and on related subjects. The material offered in the book lacks, most of all, proper arrangement and method. But this is in part compensated for by the frequent illustration of the argument by cases from actual experience. The lack of proper arrangement makes it difficult to briefly characterize the contents. In a general way, they present an argument for careful engineering study as a basis for fixing rates, etc., and also an emphatic protest against applying the methods of "high finance" to public service enterprises.

STATE BOARD OF HEALTH OF OHIO.—Report for the Year 1902. Columbus, O.: C. O. Probst, M. D., Secretary. Cloth; 7 × 10 ins.; pp. 508; tables and diagrams.

The action of the board on plans for water supply, sewerage, water and sewage purification and garbage disposal is set forth in this report. There are also included water analyses by Mr. E. G. Horton, Chemist and Bacteriologist to the Board. An appendix consists of the third "Report on the Public Water Supplies of Ohio," by Mr. Benj. H. Flynn, since deceased. The waterworks supplying the various municipalities of the state are briefly described.

STATE BOARD OF HEALTH OF NEW JERSEY.—Report for 1902. Trenton, N. J.: Henry Mitchell, M. D., Secretary. Cloth; 6 × 9 ins.; pp. 682; tables.

The routine work here reported on includes stream inspection of the Hackensack and Rahway rivers. The vital statistics of the state for the year 1902 are included in the volume.

*Ready October 15th*

**A TREATISE ON CONCRETE, PLAIN AND REINFORCED**

Materials, Construction and Design of Concrete and Reinforced Concrete, with chapters by R. Feret, William B. Fuller, and Spencer B. Newberry. By Frederick W. Taylor, M.E., and Sandford E. Thompson, Assoc. M. Am. Soc. C. E.

8vo. Many illustrations. 400 to 500 pages. Cloth.

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THE COALS OF ILLINOIS: THEIR COMPOSITION AND ANALYSIS.—By S. W. Parr, M. S., Professor of Applied Chemistry, University of Illinois. Bulletin No. 9. Urbana, Ill.: University Press. Paper; 7 × 10 ins.; pp. 44; illustrated. 25 cts.

The text of this excellent monograph is primarily of value to the chemist having coal analyses to make; but the tables of composition and heat value of 150 different samples of Illinois coals should prove of value to engineers. The tables give analyses of "slack," "lump," "nut," etc., and show a great range of calorific value, from 8,645 B. T. U. for a certain sample of "slack," to 13,303 B. T. U. for a certain sample of "lump."

THE BARABOO IRON-BEARING DISTRICT OF WISCONSIN.—Bulletin No. XII., Wisconsin Geological and National History Survey. By Samuel Weidman, Ph. D. Madison, Wis.: Director of the Survey. Cloth; pp. 200; illustrated, including map of district; cloth, 20 cts.; paper, 10 cts.

To all interested in the iron deposits of Wisconsin, this excellent monograph will be of value. The discussion of the origin of the iron ore deposits is certain to be of interest to geologists generally. The author gives data and reasons based thereon to show the iron ore is largely an original sedimentary deposit of limonite. Numerous chemical analyses are given of the ores, of the country rocks, and also of the ground water.

THE PRODUCTION OF ASPHALTUM AND BITUMINOUS ROCK IN 1903.—By Edmund Otis Hovey. Washington: U. S. Geological Survey. Paper; 6 × 9 ins.; pp. 14.

This pamphlet gives the statistics of production, importation and value of asphaltum and bituminous rock.

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## Hoisting Machinery.

AN ELEMENTARY TREATISE ON HOISTING MACHINERY.—Including the Elements of Crane Construction and Descriptions of the Various Types of Cranes in Use. By Joseph Horner, Assoc. M. Inst. M. E. Philadelphia: J. B. Lippincott Co. London: Crosby, Lockwood & Son. Cloth; 5⅛ × 8 ins.; pp. 252; 215 illustrations, mostly in the text. $3 net.

This book has been written by an experienced designer of cranes. It presents in concise form the leading characteristics of the various types of cranes now made. The concise treatment has made it impossible to discuss any single type of crane at length, and this is perhaps the most serious defect of the book. Such a work as this will scarcely find a great sale among the users of cranes, although many facts that it contains would be of value to those who purchase hoisting machinery. Since, therefore, the designer is the one for whom the book has apparently been written, much that it contains is exasperating by virtue of its brevity. On a subject of this kind it would seem that a much larger book, treating each type of crane and derrick in detail, would ultimately become a necessity to all engineers engaged in designing such machinery. However, the title implies and the author clearly states in his preface, that only the elements of crane design are given in the book. The author has very properly refrained from attempting to write a treatise on graphical statics or a manual on mechanics, such as we often see forming part of a book of this type. He might have added somewhat more to his first chapter to show how the problems of stresses in cranes may best be attacked, and to what extent theoretical calculations are applicable in the design of crane parts. Factors of safety used in designing different details should have been stated, and, in a word, the inexperienced designer should have been told how to apply his knowledge of theoretical mechanics to problems of crane design.

The book contains a considerable number of drawings, some showing general designs, some showing details; but, almost without exception, dimensions are omitted. This is a serious defect, no matter how elementary the book may have been designed to be. Taking, for example, the cuts in the chapter on hooks and snatch-blocks: one can find almost the same class of illustrations in catalogues. The text of this chapter, however, is, fortunately, somewhat better than the illustrations. So one might go through the book, chapter by chapter, finding fault mostly with what has been left unsaid.

There are classes of books, written to give students a bird's-eye view of engineering structures, which serve well as an introduction to a subsequent exhaustive study of the particular class of structures that the student may be called upon to design after graduation; but it seems to us that a book like this, on a subject about which so little is to be found in books, should not be made one of the "bird's-eye view" class. Nevertheless, since there is a dearth of books on hoisting machinery, it is but just for us to add that every designer of such machinery should possess all that has been written upon the subject, since one little hint may be worth to him many times the cost of the book. This is more particularly true where the author of a book is himself a man experienced along the lines about which he has written.

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IOWA ENGINEERING SOCIETY.—Proceedings of the Meeting at Des Moines, Ia., Jan. 20 to 22, 1904. Iowa City, Ia.: Arthur J. Cox, Secretary. Paper; 6 × 9 ins.; pp. 156; folding plates and other illustrations. 50 cts.

Among the subjects presented at the meeting reported herein are river improvements, street intersections, a new reinforced concrete bridge, structural iron work, sewerage and railway construction and sanitary engineering.

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THE MICHIGAN TECHNIC, 1904.—Ann Arbor, Mich.: The Engineering Society of the University of Michigan. Paper; 6 × 9 ins.; pp. 114; plates and figures in the text.

Well-executed portraits of the late Prof. C. E. Greene, of Dean Cooley and of Prof. J. B. Davis are given in the front part of this volume. There is an obituary notice of Professor Greene and biographical sketches of Dean Cooley and of Professor Davis. The sketch of Dean Cooley was prepared by Professor Davis.

Among the subjects of the papers included in the volume are drafting room systems, locomotive road tests, cement manufacture, tests of lubricating oils and of a kerosene engine, and the value of gas analysis in gas engine tests.

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THE BUILDING ESTIMATOR.—By William Arthur. Omaha, Neb.: William Arthur. Cloth; 4 × 6 ins.; pp. 150; tables and 15 illustrations. $1.50.

The author of this little book has succeeded in crowding a great deal of valuable cost data into a small space. As indicated by its title, the book has been written especially for building contractors and architects. The author is himself a building contractor, and is, therefore, a better authority on costs than he would otherwise be. He has given numerous examples from his own experience, but has also drawn from technical literature.

In the space of about 125 pages the author discusses the detailed estimating of the following items: Excavation; piling; concrete; stonework; brickwork; municipal work; fire-proofing; plaster; carpenter and joiner work; millwork and glass; glass; structural steel and iron; tin, galvanized iron, copper, etc.; roofing; painting, hardware; plumbing and gas fitting; heating and lighting; tiling; odds and ends; a standard 10-stall engine house; square foot and cubic foot prices.

The book is indexed, though not as completely as may be desired. Some twelve buildings erected by the author are illustrated by photographs, in order to give a general idea of the classes of construction upon which prices are given in the text. The author makes free use of abbreviations that are not always clear, and certainly not by any means standard, and the abbreviations are more apt to be confusing due to the absence of periods; thus, ci is used to denote cubic inches; ps, to denote piece; sq, to denote 100 sq. ft. In spite of certain defects, the book appears to be the most complete of its class yet published, although it suffers, as do most "estimators' handbooks," by virtue of too great condensation and the frequent omission of statements as to rates of wages and local conditions.

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THE STEEL SQUARE POCKET-BOOK.—A Practical and Handy Treatise, Giving the Best and Simplest Methods of Using the Carpenter's Steel Square. By Dwight L. Stoddard. New York: Industrial Publication Co. Cloth; 3½ × 5 ins.; pp. 109; 112 figures in the text. 50 cts.

This little book has been written particularly for carpenters. The author explains in clear language the ways in which he uses his own square for laying out work. The book is profusely illustrated with line cuts, there being an average of more than one to the page. In fact, the text is simply an explanation of each of the 112 figures.

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CAR WIRING SUPPLEMENT, NATIONAL ELECTRICAL CODE.—Rules and Requirements of the National Board of Fire Underwriters for the Equipment and Wiring of Electric Railway Cars. National Board of Fire Underwriters, 32 Nassau St., New York City. Paper; 3½ × 5¾ ins.; pp. 14.

The rules here given (edition of 1904, Supplement to the National Electrical Code of 1903) were formulated by a committee from the Underwriters' National Electric Association in conference with a committee of the American Street Railway Association. They have been adopted by the National Board of Fire Underwriters for governing the wiring and equipment of steel railway cars. Copies of the pamphlet may be secured by addressing the National Board of Fire Underwriters, 32 Nassau St., New York City.

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WESTERN RAILWAY CLUB.—Proceedings for 1903-4. Secretary, J. W. Taylor, Rookery Building, Chicago. Cloth; 6 × 9 ins.; p. 312; illustrated.

Some of the subjects of papers and discussions are as follows: Water treatment in railway operation; train pipe leakage; machine tools and high-speed steel; the manufacture of boiler tubes; the influence of brain power on dividends; steel in car construction; the technical graduate and the railway mechanical department; steel axles; the electric headlight. There are also topical discussions on the rules of interchange and the fitting of grab irons to engines and tenders.

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POCKET-BOOK OF USEFUL FORMULAS AND MEMORANDA FOR CIVIL AND MECHANICAL ENGINEERS.—By Sir Guilford L. Molesworth, Prest. Inst. C. E., M. Inst. M. E., and Henry Bridges Molesworth, M. Inst. C. E. Twenty-fifth Edition, Revised and Enlarged With an Electrical Supplement by Walter H. Molesworth. London: E. & F. N. Spon. New York: Spon & Chamberlain. Leather; 3 × 5 ins.; pp. 851; many tables and illustrations. $2.

A book that passes to its twenty-fifth edition in a little more than thirty years must either have or have had much to commend it, or else lack competitors in a field in which a book is much needed. For the British engineer it may be presumed that for many years "Molesworth's Pocket-Book" met both these conditions. However that may have been, it now needs extensive additional revision. That it possesses little value for American and not much for Canadian engineers can scarcely be laid up against the author and the revisers, since it has been prepared and revised, like so large a percentage of British technical books, with only Britishers in mind.

One of the chief faults of the book, for users anywhere, is that much of the data presented is not only very old, but also that its age, and consequent diminished usefulness, is in no way indicated. Thus, we have on p. 99, "Conclusions derived from Mr. Grant's Experiments" on Portland cement, but not a hint that these were the earliest scientific experiments of value on cement ever made, and that conclusions based on them are now far behind the times. On p. 100 it is stated that "cement should be ground to pass through a sieve of 2,500 meshes per square inch." Although the British do not grind cement as fine as either the Germans or the Americans, they now grind it finer than indicated by the statement quoted.

On p. 296 appears the following strange paragraph:

> Bacterial Treatment of Sewage.—Fresh sewage is turned into a specially prepared covered bed charged with the bacteria, and kept in contact with them for a short time. The bed is charged with sewage twice a day, and the effluent filtered.

This misleading statement is followed by a definition of the "Alumino-ferric Process," which might far more properly have given place to a definition of chemical precipitation, with a statement that alumino-ferric is one of several chemicals used as a precipitant.

A half of p. 301 is devoted to "Amherst Ship Railway (Sir B. Baker)." This is really a description of the old Chignecto Ship Railway project. The railway was never built, but few readers not aware of that fact would even infer it from the pocket-book.

The electrical section of the work is brief, and not arranged to the best advantage, but, having been added recently, it is more up-to-date than the other portions of the pocket-book.

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WATER SUPPLY AND IRRIGATION PAPERS.—United States Geological Survey, Charles D. Walcott, Director. Washington, D. C.: Pub. Docs. Paper; 6 × 9 ins.

No. 89: Water Resources of the Salinas Valley, California. By Homer Hamlin. Pp. 91; tables, 12 plates and 30 figures in the text.

No. 90: Geology and Water Resources of Part of the Lower James River Valley, South Dakota. By J. E. Todd and C. M. Hall. Pp. 47; tables, folding and other plates and two maps in pocket.

No. 93: Proceedings of First Conference of Engineers of the Reclamation Service, with Accompanying Papers. Compiled by F. H. Newell, Chief Engineer. Pp. 361; one figure in the text.

No. 94: Hydrographic Manual of the U. S. Geological Survey. Prepared by Edward C. Murphy, John C. Hoyt and George B. Hollister. Pp. 73; tables, 3 plates and 10 figures in the text.

In Mr. Hamlin's paper (No. 89), cross-sections of several proposed rock-fill dams, designed by engineers of the Survey, are given. An earth dam, to be made watertight by means of an inclined layer of natural bituminous sandstone, is also figured. This layer would have its toe in a concrete cut-off wall at about one-third of the distance between the foot of the river and outer slope. The bituminous stone would come from a quarry 6½ miles up-stream

The conference of engineers engaged in the reclamation service was held at Ogden, Utah, September 15 to 18, 1903. About 25 engineers, or a tenth of the number in the field, were present. This volume outlines the organization of the hydrographic branch of the U. S. Geological Survey, and contains brief biographical notes of each member of the engineering force engaged in the reclamation service. The papers and discussions at the conference included various phases of the reclamation service, such as specific projects, electrical transmission, cement, alkaline lands, water laws, the use of the plane table, and the design of masonry dams.

The "Hydrographical Manual" (No. 94) contains instructions for field and office work in connection with the gaging of streams by the use of current meters. A later bulletin will contain similar instructions for gaging by means of weirs and dams. The author-committee have here endeavored to bring together all the available information for the gaging of streams developed in the practice of the engineers and hydrographers of the Geological Survey, and the publication is intended mainly for the use of those connected with the survey. But others interested in hydraulic problems will find in it much that is valuable to them.

The instructions for field operations cover the selection of stations and their classification and equipment, the gages, bench-marks, measurements of depth and velocity, checks, discharge measurements, etc. Then follows a chapter on the description and care of instruments. Records and reports and standard forms precede a chapter on computations, and a series of useful tables completes the manual.

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MERSEY & IRWELL JOINT COMMITTEE.—Report of R. A. Tatton, M. Inst. C. E., Chief Inspector, May, 1904. Manchester, England: The Committee. Paper; 6 × 8 ins.; pp. 12; folding diagram and folding sheets of tables.

The Mersey & Irwell Committee has sanitary jurisdiction of four rivers in the vicinity of Manchester, on the drainage area of which is a population of 2,500,000, distributed among 93 municipalities. There are also 444 industrial plants under the jurisdiction of the committee. These plants do not include those connected with municipal sewerage systems. All but five of the municipalities and all but five of the manufactories have sewage treatment works. The report contains fairly detailed tabular descriptions of the 90 municipal sewage works, including statements of the number of samples which, on chemical analysis, were found to be above, and also the number below the standard set by the board. The number below is far in excess of the number above the standard. The standard is not defined.

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RHODE ISLAND COMMISSIONER OF DAMS AND RESERVOIRS.—Report for 1903. Walter C. Simmons, Commissioner. Providence, R. I.: Pub. Doc. Paper; 6 × 9 ins.; pp. 33; folding and other plates.

Several new dams are described and illustrated in this report, and specifications for two of them are given.


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## The Literary Magazines.

Honest men will approve most that Mr. George W. Alger says in the August "Atlantic," under the title of "Unpunished Commercial Crime." The burden of the article is that elementary and "ancient" crimes are punished, particularly when against the life of the individual, but that crimes against society either go unpunished or as a rule are subject to light punishment. Among other striking illustrations in support of his thesis the author says:

> The man who, after inducing the business world to give him credit for many thousands of dollars, transfers his property in order to swindle those who have trusted in him, may be punished with no greater severity than the man who expectorates on the floor of a public conveyance.

Some remarkable natural bridges are described by Mr. W. W. Dyar in the "Century." The bridges are located near the head of White Canyon, in San Juan Co., Utah. The largest bridge has a span of 335 ft. and a clear height, to the under side of the arch, of 357 ft. It is believed that these natural bridges were first seen by white men in 1895. The notes on which the article is founded were made in 1902 by Mr. Horace J. Long, a mining prospector. Some effective illustrations, drawn by Mr. Harry Fenn from photographs, accompany the article. Under the title, "The Plan of New York, and How to Improve It," Mr. Ernest Flagg suggests in "Scribner's" that portions of each side of Central Park be sold to realize money for the purchase and development of a grand north and south parkway to extend nearly the whole length of Manhattan Island.

The "Cosmopolitan" contains an article on "Simon Lake and His Wonderful Submarine," in which the invention and working boats of Mr. Lake are described, and the U. S. Government is taken to task for the way in which it has handled submarine boat matters. The same magazine has an article on "Railroads Above the Clouds," which, translated, means mountain railways. "Sunset," published at San Francisco, and somewhat given to booming the West, although mostly in a quiet way, contains an article by James F. O'Brien, entitled "Nevada's Latest Bonanza," which is located at a mining camp with the alluring name of "Goldfield."

A special double number of "The World's Work" is almost wholly devoted to the St. Louis Exposition. Hundreds of illustrations and staff and other articles are employed to set forth the attractions and lessons of the fair in graphic form. The "Review of Reviews" contains an article on "Wireless Telegraphy in Practical Operation." The leading article in "The North American Review" is "The Baltic Fleet and the Northeast Passage," by Rear-Admiral Geo. W. Melville. In it the author discusses, at the request of the editor, "the practicability of the use of the Northeast Passage through the Arctic Ocean by the Russian fleet in transit from the Baltic to the Pacific." The point of view adopted, however, is that "of an Arctic explorer, who, for almost two years, ice-beset in the 'Jeanette,' drifted to and fro over perhaps the most exposed and dangerous portion of this possible route." From such a view-point, and without considering "the military advisability or necessity of such an effort," Admiral Melville concludes that such a voyage would be practicable.

About the usual percentage of articles on the war in the East and other military questions appear in the "Contemporary" and "Fortnightly" reviews and in "The Nineteenth Century and After." The last-named review contains an article on "Medicated Air."

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CAR SANITATION.—By James A. Exton, M. D., Surgeon Erie R. R. From The International Journal of Surgery, June, 1904. Arlington, N. J.: The Author. Paper; 5 × 8 ins.; pp. 15.

This is a paper read in 1903 before several meetings of railway surgeons. It contains a number of sensible ideas on car sanitation, and some plain practical directions for disinfecting cars. The author also describes a "hospital kit," which he suggests should be a part of the equipment of every passenger train. This kit, he has found by experiment, could be put in a box 4 × 20 ins., × 5 ins. deep.

## Publications Received.

PROFESSIONAL PAPERS OF THE U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; [illegible] 12 ins.

No. 21: The Geology and Ore Deposits of the Bisbee Quadrangle, Arizona. By Frederick Leslie Ransome. Pp. 168, 29 plates and 5 figures in the text.

No. 22: Forest Conditions in the San Francisco Mountains Forest Reserve, Arizona. By John B. Leiberg, Theodore F. Rixon and Arthur Dodwell. With an Introduction by A. G. Plummer. Pp. 95; 7 plates.

No. 23: Forest Conditions in the Black Mesa Forest Reserve, Arizona. Prepared by A. G. Plummer from Notes by Theodore F. Rixon and Arthur Dodwell. Pp. 62; 7 plates.

No. 28: The Superior Analyses of Igneous Rocks. From Roth's Tabellen, 1869 to 1884. By Henry Stephens, Washington. Pp. 98.

BULLETINS U. S. GEOLOGICAL SURVEY.—Charles D. Walcott, Director. Washington, D. C.: Pub. Doc. Paper; 6 × 9 ins.

No. 226: Boundaries of the United States and of the Several States and Territories, with an Outline of the History of all Important Changes of Territory. (Third Edition.) By Henry Gannett. Pp. 145; 54 folding and other plates.

No. 228: Analyses of Rocks from the Laboratory of the United States Geological Survey, 1880 to 1903. Tabulated by F. W. Clarke, Chief Chemist. Pp. 375; tables.

No. 229: The Tin Deposits of the York Region, Alaska. By Arthur J. Collier. Pp. 61; 7 plates and 5 figures in the text.

No. 230: A Gazetteer of Delaware. By Henry Gannett. Pp. 15.

No. 231: A Gazetteer of Maryland. By Henry Gannett. Pp. 84.

GEOLOGIC ATLAS OF THE UNITED STATES.—No. 107, Newcastle Folio: Wyoming—South Dakota. U. S. Geological Survey, Charles D. Walcott, Director. Stiff paper; 18 × 22 ins.; pp. 9; half-tones and colored maps. Also No. 108, Edgmont Folio: South Dakota—Nebraska. Do., do.; pp. 10.

ILLINOIS FREE EMPLOYMENT BUREAU.—Report for 1902-3. Springfield, Ill.: Bureau of Labor Statistics. Paper; 6 × 8¾ ins.; pp. 81.

REPORT OF THE CHIEF OF THE U. S. WEATHER BUREAU, 1902-3.—Willis L. Moore, Chief. Washington, D. C.: Department of Agriculture. Cloth; 9 × 12 ins.; pp. 308; many tables.

ASSOCIATION OF TRANSPORTATION AND CAR ACCOUNTING OFFICERS.—G. P. Conrad, Secretary, 24 Park Place, New York City. Paper; 6 × 9 ins.; pp. 154.

GEOLOGICAL SURVEY OF NEW JERSEY.—Annual Report of the State Geologist, Hon. Henry B. Kümmel, for the year 1903. Trenton, N. J.: Pub. Doc. Boards; 6 × 9 ins.; pp. 132; large folding map and other illustrations.

PITFALLS OF MINING FINANCE.—By Harry J. Newton, for many years Managing Editor of "The Daily Mining Record." Denver, Colo.: "The Daily Mining Record." Paper; 6 × 8½ ins.; pp. 156.

A TRUE POLICY OF PROTECTION.—A Treatise Prepared for Submission to the Boston Chamber of Commerce and other merchants, and to manufacturers. By Edward Atkinson, Boston, Mass.: The Author. Paper; 6 × 9 ins.; pp. 59.


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THEORIE UND PRAKTISCHE BERECHNUNG DER HEISSDAMPFMASCHINEN.—Mit Einem Anhange Uber die Zweicylinder-Condensations-Maschinen mit Hohen Dampfdruck. Von Josef Hrabak. Berlin: Julius Springer. Cloth; 8 × 11 ins.; pp. 100; tables. 7 marks or $2.80.


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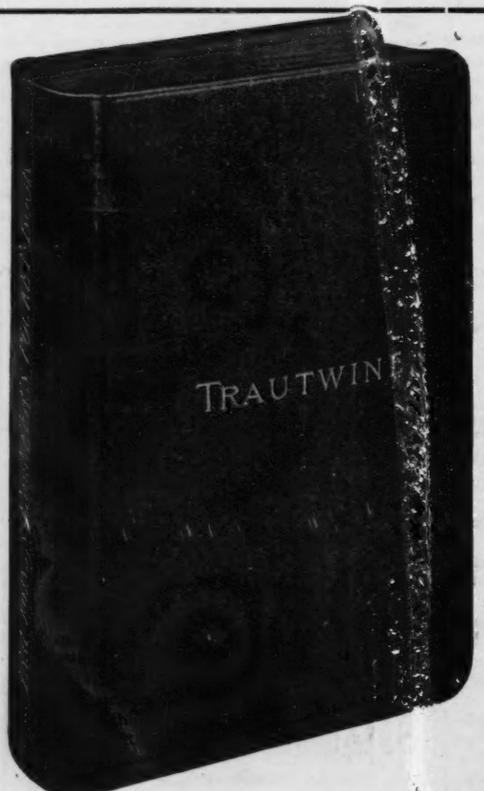


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